AD-A060 871 ARMY MATERIEL SYSTEMS ANALYSIS ACTIVITY ABERDEEN PROV--ETC

PARAMETRIC ANALYSIS OF MAIN BATTLE TANK MOBILITY IN KOREAN TERR--ETC(U)

OCT 78 W A NIEMEYER, R C THIBODEAU

NL

UNCLASSIFIED AMSAA-TR-237

1 OF 1

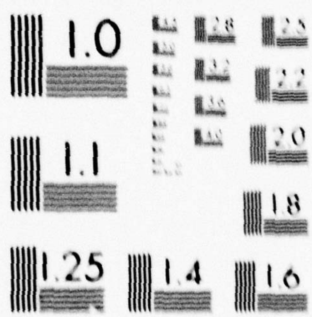
AD A060 871

END

DATE FILMED

1-79

DDC



MICROCOPY RESOLUTION TEST CHART

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: TR-237 ✓

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

(9)

4. TITLE (and Subtitle)

(6) Parametric Analysis of Main Battle Tank Mobility in Korean Terrain.

5. TYPE OF REPORT & PERIOD COVERED: Final rept.,

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)

(10) William A. Niemeyer
Robert C. Thibodeau

8. CONTRACT OR GRANT NUMBER(s)

(16) 1R765706M541

9. PERFORMING ORGANIZATION NAME AND ADDRESS

US Army Materiel Systems Analysis Activity
Aberdeen Proving Ground, MD 21005

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

DA Project No
1R76506M541

11. CONTROLLING OFFICE NAME AND ADDRESS

Commander
US Army Materiel Development and Readiness Command
5001 Eisenhower Avenue
Alexandria, VA 22333

12. REPORT DATE

(11) October 1978

13. NUMBER OF PAGES

59

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

(14) AMSAA-TR-237

15. SECURITY CLASS. (of this report)

UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

UNCLASSIFIED

16. DISTRIBUTION STATEMENT (of this Report)

(12) 60p.

Approved for public release, distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Combat Vehicles	Mobility Modeling
Main Battle Tanks	Automotive Performance
Mobility	Korean Terrain

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report evaluates, through parametric component variation, the mobility potential of a series of main battle tank configurations operating in Korean terrain. Four principal design areas are varied, including the power train, suspension, weight and hull geometry. The speed potential of each vehicle configuration is determined throughout the terrain spectrum, and non-negotiable terrain is identified. Diagnostic analysis indicates the factors causing speed limitation as well as the reasons when the terrain is impassable. Some detail is provided on the soft soil mobility of the various configurations and the significance of differences on the basis of Korean seasonal soil strength.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED 403 910

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

78 11 01 076

LB

TABLE OF CONTENTS

Next page is blank

LIST OF FIGURES

Next page is blank

LIST OF TABLES

Next page is blank

PARAMETRIC ANALYSIS OF MAIN
BATTLE TANK MOBILITY IN KOREAN TERRAIN

1. INTRODUCTION

This report evaluates, through parametric component variation, the mobility potential of a series of main battle tank configurations operating in Korean terrain. Four principal design areas are varied, including the power train, suspension, weight and hull geometry. The Korean terrain as characterized by the Waterways Experiment Station, Vicksburg, Mississippi, is statistically described, and the methodology for modeling vehicle performance is summarized.

The speed potential of each vehicle configuration is determined throughout the terrain spectrum, and non-negotiable terrain is identified. Diagnostic analysis indicates the factors causing speed limitation as well as the reasons when the terrain is impassable. Some detail is provided on the soft soil mobility of the various configurations and the significance of differences on the basis of Korean seasonal soil strength.

2. MODEL DESCRIPTION

The computer simulation used to evaluate the vehicle/terrain interaction and predict mobility performance is the Army Mobility Model (AMM). This model considers vehicle performance in both areal and linear type terrain features. The areal mobility prediction part of the model (which is the only portion used in this evaluation) is shown schematically in Figure 1. The fundamental operation of this model is as follows. Detailed areal terrain data are collected from existing terrain data sources such as topographical maps, air photos, terrain studies, agricultural data and soil maps. Where possible these data sources are supplemented by actual field surveys. All these data sources are then used to develop a series of individual maps of the area being considered for each of the terrain factors shown in Figure 1.

The terrain input processor accepts these maps and overlays them to define areas in which the terrain is homogeneous with respect to all of the terrain factors simultaneously. The result of this process is an areal terrain unit map as shown, where unit number 98 might reflect an area where the slopes are uniformly between 5 and 10 percent and the soil strength in the wet season is uniformly between 40 and 60 cone index, etc. Associated with each map unit number is a range of values for each of 14 terrain factors. The factor categories are shown in Table 1.

The model requires a total of 76 vehicle characteristic inputs. These range from vehicle size and weight to details of its power train and suspension components. With these data the various mathematical submodels of the overall model predict vehicle performance in the terrain factor values established for each map unit.

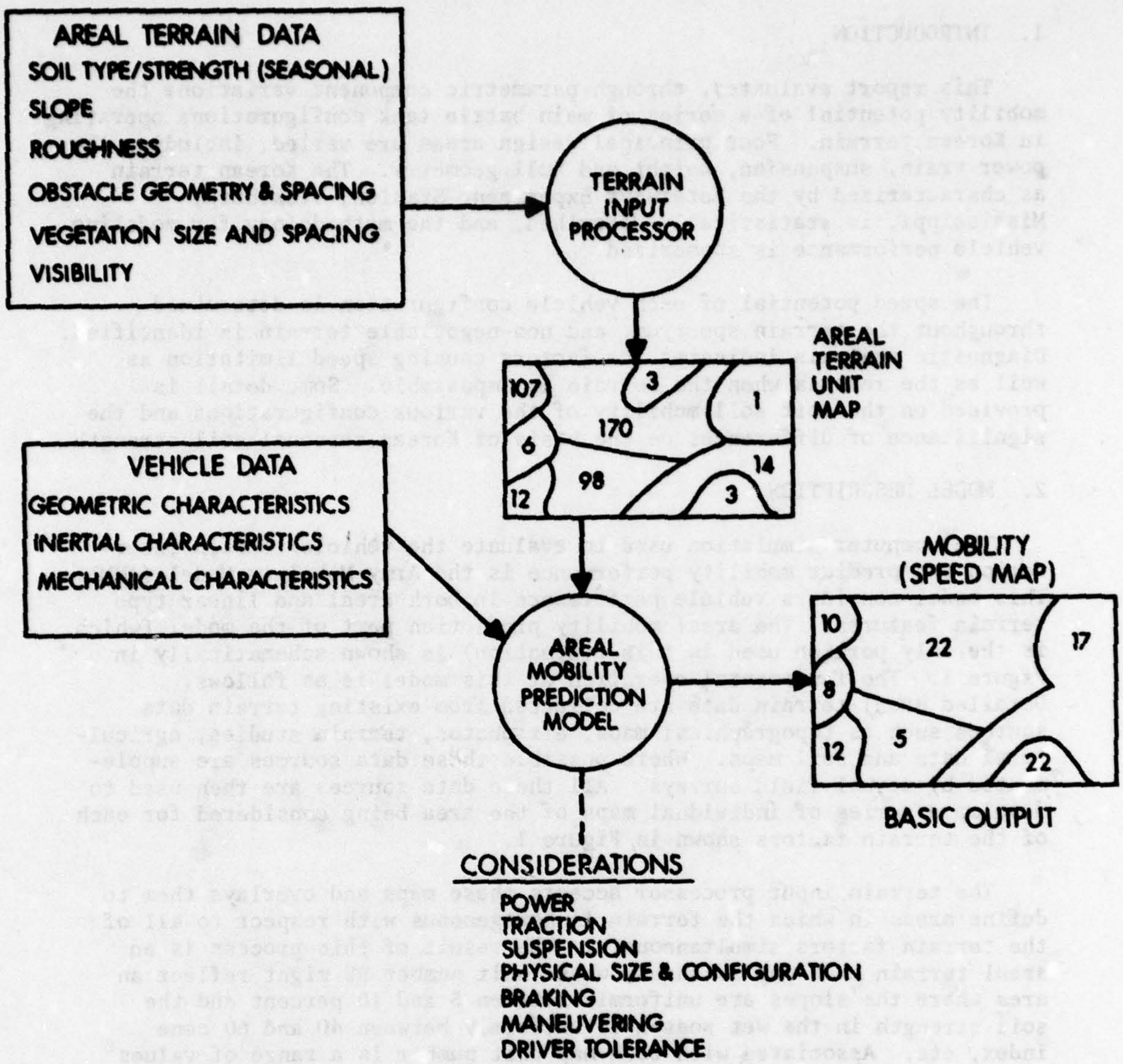


Figure 1. AMC Mobility Model (Areal Mobility Prediction)

TABLE 1 - TERRAIN CLASSIFICATION SYSTEM

TERRAIN FACTORS	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Surface Type	Fine Grained (other)	Coarse Grained	Muskeg	CH										
Surface strength (CI or RCI) Class range	201-300	221-280	161-220	101-160	61-100	41-60	33-40	26-32	17-25	11-16	4-10			
Slope (%) Class Range	1-2	3-5	6-10	11-20	21-40	41-60	61-70	70-90						
Obstacle approach angle (Deg) Class range	179	181	176-178	182-184	171-173	185-190	159-170	191-202	149-158	203-211	136-148	212-225	90-135	226-270
Obstacle vertical mag (in) Class range	1-6	7-10	11-14	15-18	19-24	25-32	33-45	46-60						
Obstacle base width (in) Class range	40-150	36-47	24-35	12-24	6-12									
Obstacle length (ft) Class range	1	2-3	4-6	7-10	11-20	21-40	41-100							
Obstacle spacing (ft) Class range	190	66-197	37-65	26-36	19-25	13-18	9-12	2-8						
Obstacle spacing type	Random	Continuous												
Surface roughness x 10 (RMS in.)	1	2-4	5-6	7-8	9-12	13-16	17-22	23-32	33-45					
Stem diameter (in.) Factor value	0	> 1	> 2.4	> 3.9	> 5.3	> 7.0	> 8.7	> 9.8						
Stem (ft) Spacing	328	66-327	36-65	26-35	18-25	13-17	8-12	1-7						
Visibility (ft) Class range	165-300	77-164	39-76	30-38	20-29	16-19	10-15	6-9	1-5					
Urban Code	Village	Town	City	Not Urban										

Submodels consider vehicle performance in the following manner:

Terrain Factors Considered	Vehicle Performance Predicted
Soil Type Soil strength Slope	Tractive and resistance forces throughout speed range.
Terrain roughness	Ride limited speed
Obstacles	Hangup, traction, dynamic loading, acceleration and braking between obstacles.
Vegetation	Traction for overriding, and vehicle size for maneuvering between trees. Driver visibility.

For a given map unit the speed results of each of these submodels are compared for uphill, downhill, and level slope conditions; the limiting value is selected for each condition, and the three limiting values are averaged to provide the vehicle's estimated best speed in that map unit. In considering the vegetation factor the model examines various strategies of maneuvering around certain size trees and overriding others to obtain the best vehicle speed. Some terrain factors such as soil strength and slope naturally interact with others, so are considered simultaneously. For example, a vehicle on a soft soil slope will have less tractive force available to climb an obstacle or override a tree than it would on a level hard surface because some of its tractive force capability is used in overcoming the soft soil motion resistance and the grade resistance. The basic speed output of the model can be used to develop a speed map as shown in Figure 1.

3. TERRAIN DESCRIPTION

The terrain used in this analysis is an area approximately 12 kilometers wide and 46 kilometers long on the northeast coast, between 41° and 42° latitude. The terrain was characterized, in accordance with Table 1, by the US Army Corp of Engineers, Waterways Experiment Station. It is the only Korean terrain that has been so characterized, and it is not known to what degree it can be considered representative of that in South Korea. This terrain was originally chosen for characterization simply because there was a complete set of topographic maps available for this area and it appeared to be reasonably representative of an area in which vehicle negotiation would be practical. The subject area is shown schematically in Figure 2 and the map sheet locations are shown in Figure 3.

The area has been divided into approximately 2,000 discrete terrain units, but several of the non-contiguous units have identical

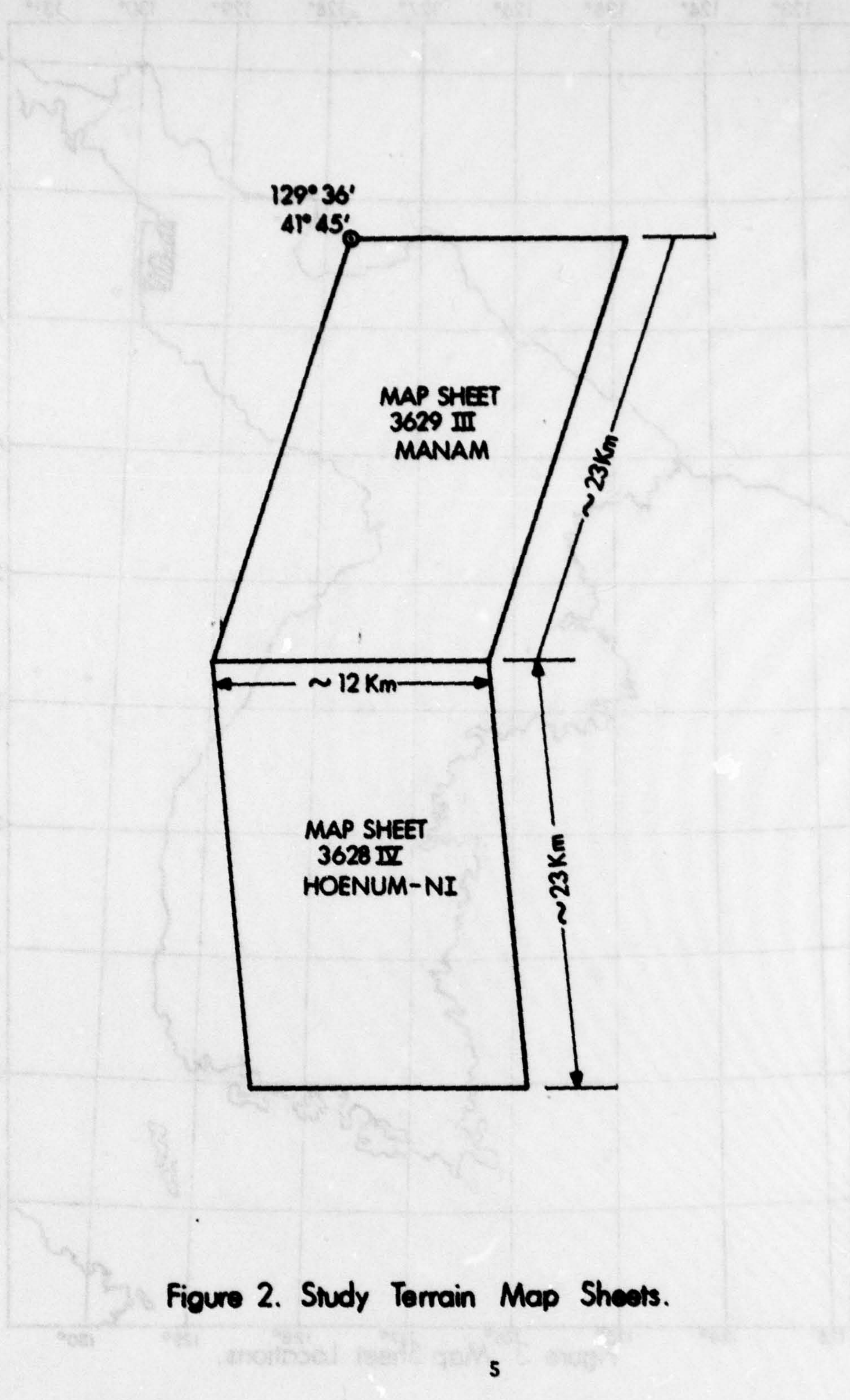


Figure 2. Study Terrain Map Sheets.

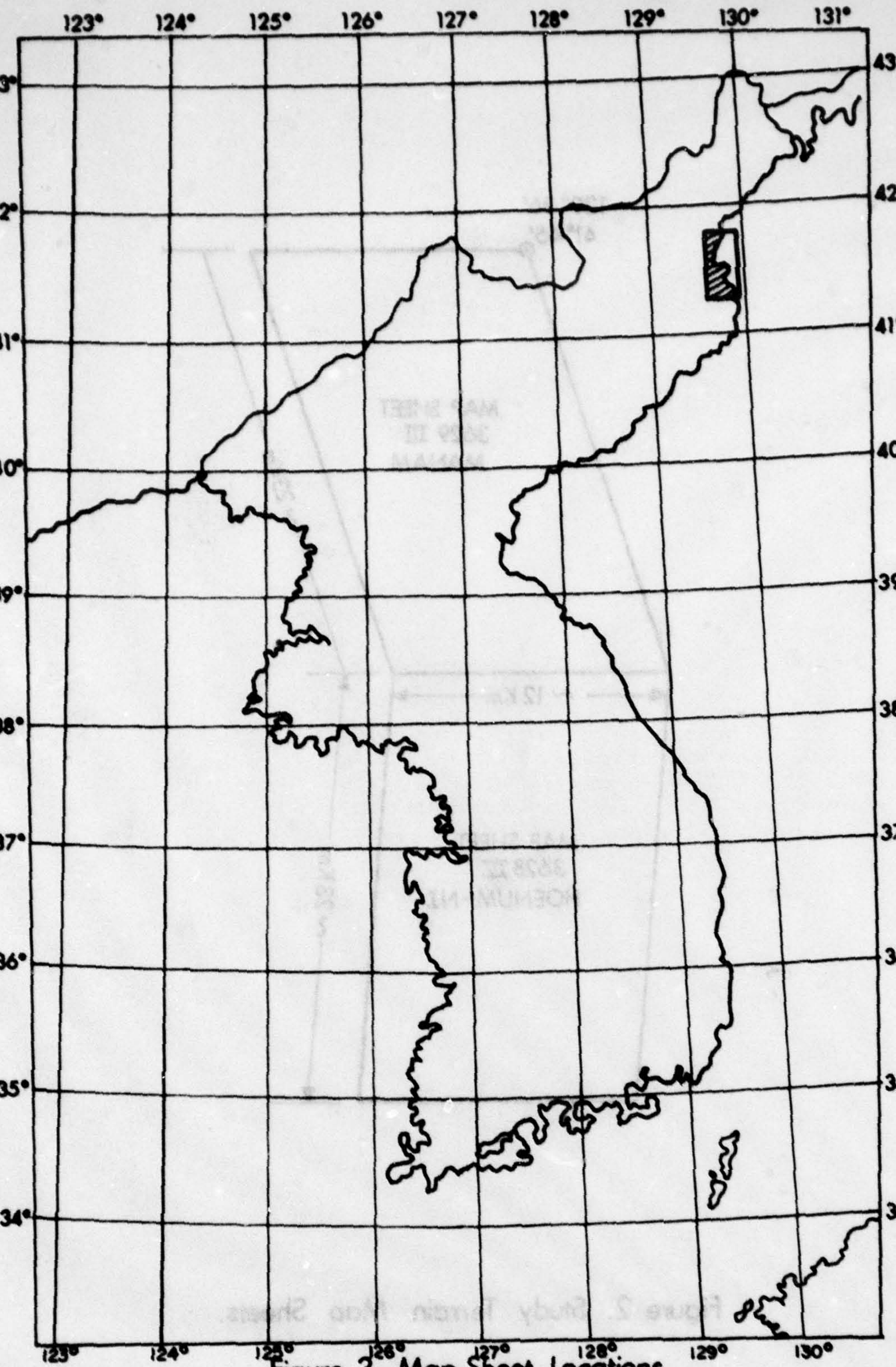


Figure 3. Map Sheet Locations.

characteristics, so that there are 1617 unique combinations of terrain factors, i.e., there are 1617 different types of terrain units that occur. Appendix A contains frequency distributions (as represented by percent area rather than number of terrain units) for the most significant factors of the terrain characterization. The area is shown to be very hilly with steep slopes, but at the same time there is a significant portion of the terrain with soil too soft to support repeated traffic of an M60. There is also a significant portion of the terrain with high surface roughness. In virtually all respects, the Korean terrain analyzed herein is more severe than the West German terrain typically used to represent European operations.

4. VEHICLE CONFIGURATIONS - PARAMETRIC VARIATIONS

There are four principal design areas that are addressed parametrically in this report. These are the power train, suspension, gross weight, and general hull configuration including both geometric and inertial characteristics. Each of these factors are evaluated at two different levels with the exception of the power train which is addressed at three performance levels. The base level in all cases represents the current M60 series design. The upper level represents the practical "state of the art" in main battle tank design and will be referred to as the "SOTA" level. The third power train level is intermediate to the upper and lower levels and is believed to represent the performance available by product improvement of the M60 engine without a transmission change.

The result of providing the variation discussed above is a matrix yielding 24 vehicle configurations. These are identified in Table 2. It may be noted that the weight levels selected are not entirely consistent with the M60/SOTA spectrum of vehicle characteristics. The lower weight level is especially artificial, but was nonetheless selected after discussions with visitors from the Republic of Korea and TARADCOM in April 1977.

5. MODELING RESULTS

The mobility model described in Section II was utilized to predict the performance of each vehicle configuration across the 1617 terrain unit types identified in the Korean terrain. The results of these analyses are presented in the form of mobility profiles in Figures 4 through 11. The profiles in Figures 5 through 7 are generated by ordering the terrain units along the horizontal axis with those providing best vehicle performance considered first (furthest to the left on this axis). The vehicle speed in each individual terrain unit is then plotted as a function of the terrain unit position on the area axis (which, as stated, is determined by trafficability). Thus the actual vehicle speed which can be obtained in, for example, the 75th percentile terrain, is depicted. Figures 8 through 11 use the same technique for arranging the terrain units, but rather than plot the actual speed in each unit, the cumulative average speed over all terrain units to the left of each point

TABLE 2 . VEHICLE CONFIGURATION MATRIX

Configuration Number	Power Train (HP)	Suspension	Weight (TONS)	Hull Configuration
1	750	M60	45	M60
2	750	M60	55	M60
3	900	M60	45	M60
4	900	M60	55	M60
5	1500	M60	45	M60
6	1500	M60	55	M60
7	750	SOTA	45	SOTA
8	750	SOTA	55	SOTA
9	900	SOTA	45	SOTA
10	900	SOTA	55	SOTA
11	1500	SOTA	45	SOTA
12	1500	SOTA	55	SOTA
13	750	SOTA	45	M60
14	750	SOTA	55	M60
15	900	SOTA	45	M60
16	900	SOTA	55	M60
17	1500	SOTA	45	M60
18	1500	SOTA	55	M60
19	750	M60	45	SOTA
20	750	M60	55	SOTA
21	900	M60	45	SOTA
22	900	M60	55	SOTA
23	1500	M60	45	SOTA
24	1500	M60	55	SOTA

on the horizontal axis is plotted. Thus from these curves one can determine the average speed of the vehicle if it is driven in, for example, the most trafficable 75 percent of the terrain, with the most severe 25 percent avoided. One further note on computational techniques - when the model determines a terrain unit to be impassable, it nevertheless assigns a vehicle speed of 0.1 mph to that unit as a computational expediency. Thus on the cumulative average speed curves, the 0.1 mph is averaged with all prior unit speeds and a finite average speed is predicted even over impassable terrain. However, reference to the actual speed curves will indicate the point at which this artificiality occurs.

In order to summarize the results shown in preceding mobility profiles, Table 3 has been included. In this table, the average speed attainable with each configuration is shown, first when operating in the most trafficable 50% of the terrain (V_{50}), and also when in the most trafficable 80% of the terrain (V_{80}). The V_{50} performance might be representative of movement potential where the unit has not been forced to tactical deployment and route selection is not restricted. The V_{80} performance might then be taken as an indicator of movement potential under tactical deployment where route selection is more restricted. These are admittedly arbitrary measures, but nevertheless are believed to provide a reasonable basis for quantifying the effects of the parametric variation of vehicle components. The final quantification of these effects is obtained by determining the average contribution across all configurations, afforded by variation of a single vehicle parameter. This is accomplished by computing the average percentage improvement in V_{50} and V_{80} when a single vehicle variable is changed from its lower performance level to the higher level (e.g. from M60 level to SOTA level, or from 55T to 45T). The results are shown in Table 4.

The addition to the speed profiles discussed above, one further product of the mobility modeling is a determination of the factor for each terrain unit that either causes the unit to be impassable, or provides the ultimate speed constraint.

Factor categories 1-4 below indicate impassability; categories 5-10 are speed constraints.

1. Soil strength insufficient

2. Available traction less than soil and slope resistance

3. Obstacle interference

4. Available traction less than total resistance (including vegetation and obstacle override).

5. Ride dynamics

6. Soil and slope resistance

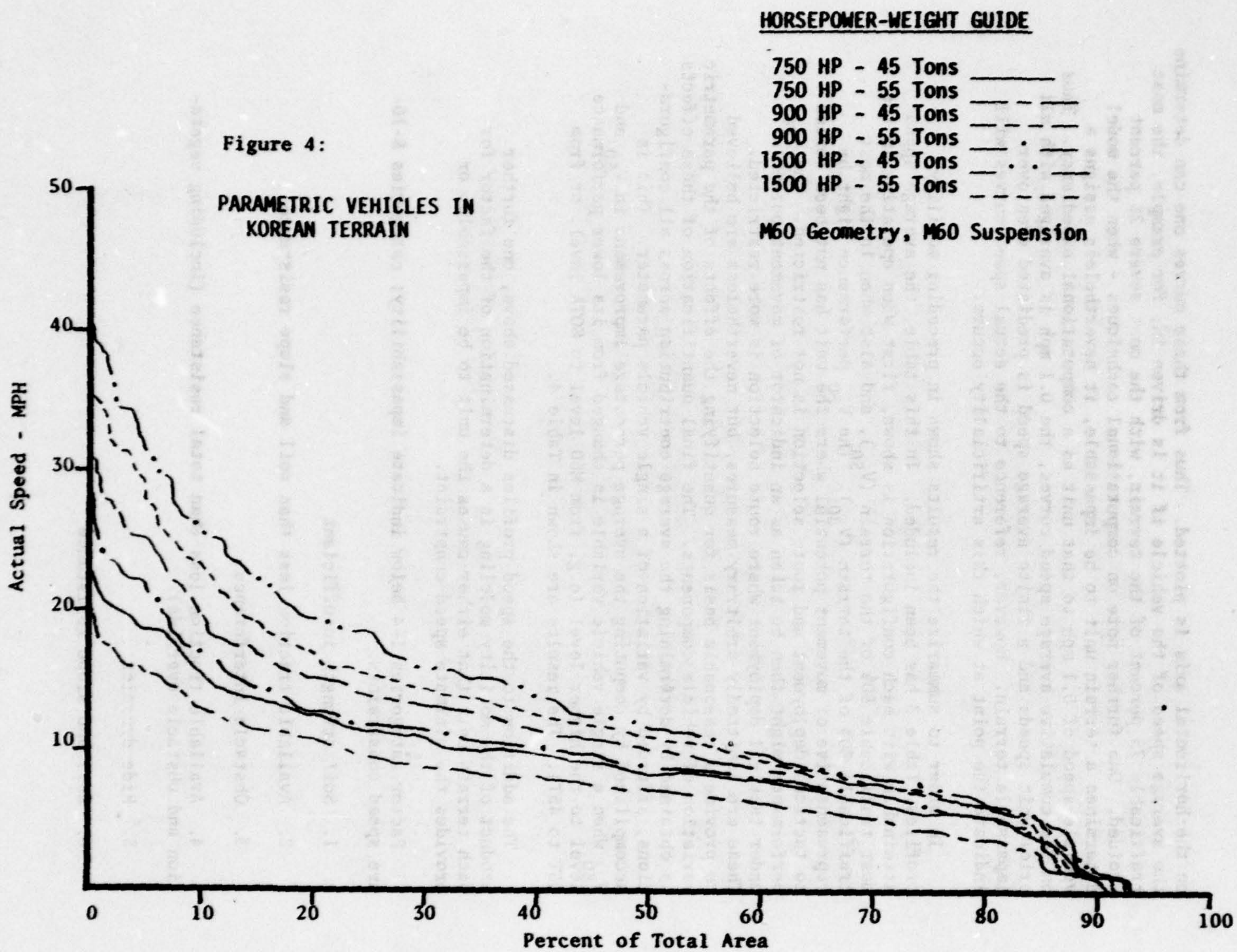


Figure 4:

PARAMETRIC VEHICLES IN KOREAN TERRAIN

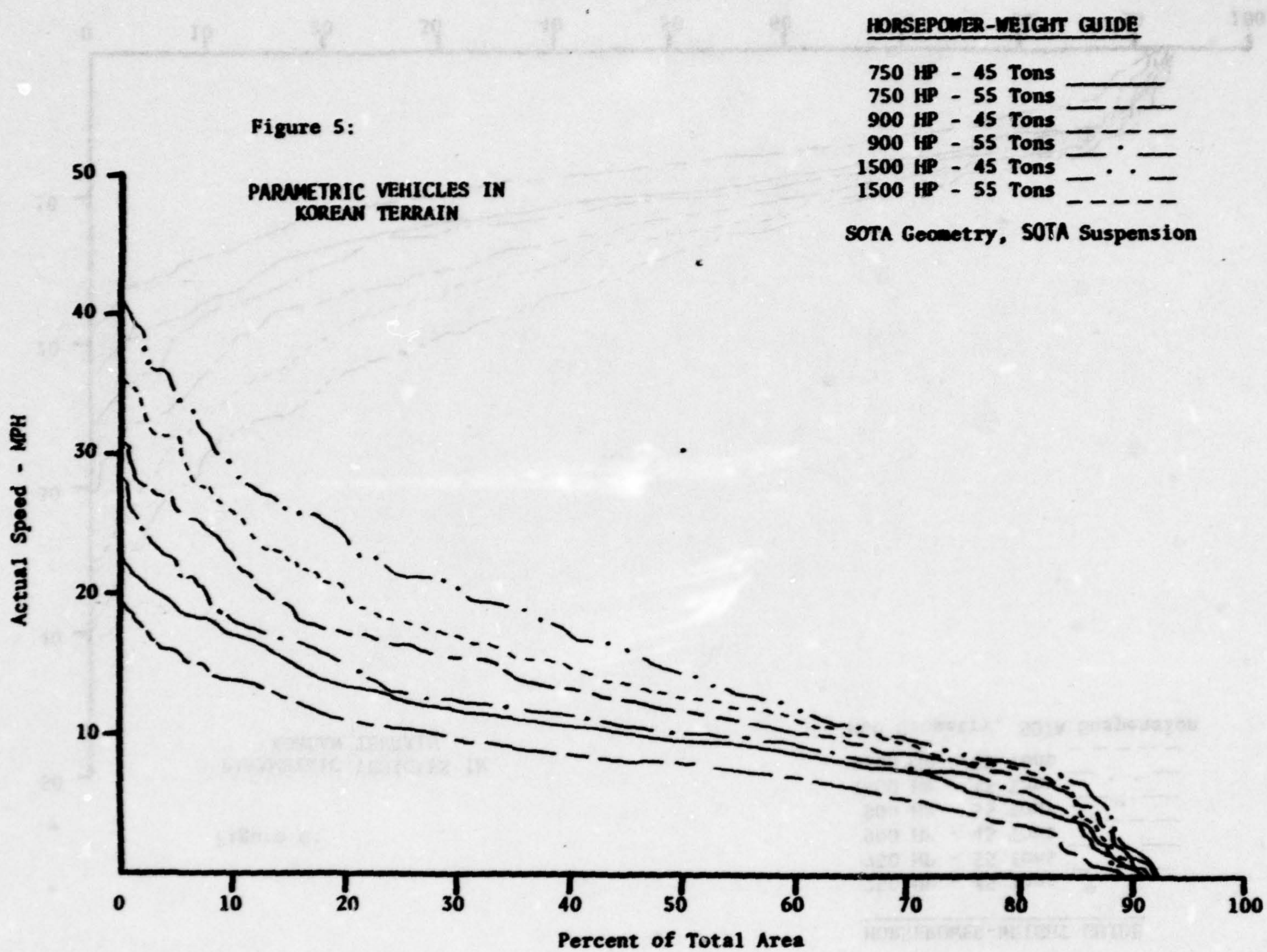


Figure 5:

PARAMETRIC VEHICLES IN KOREAN TERRAIN

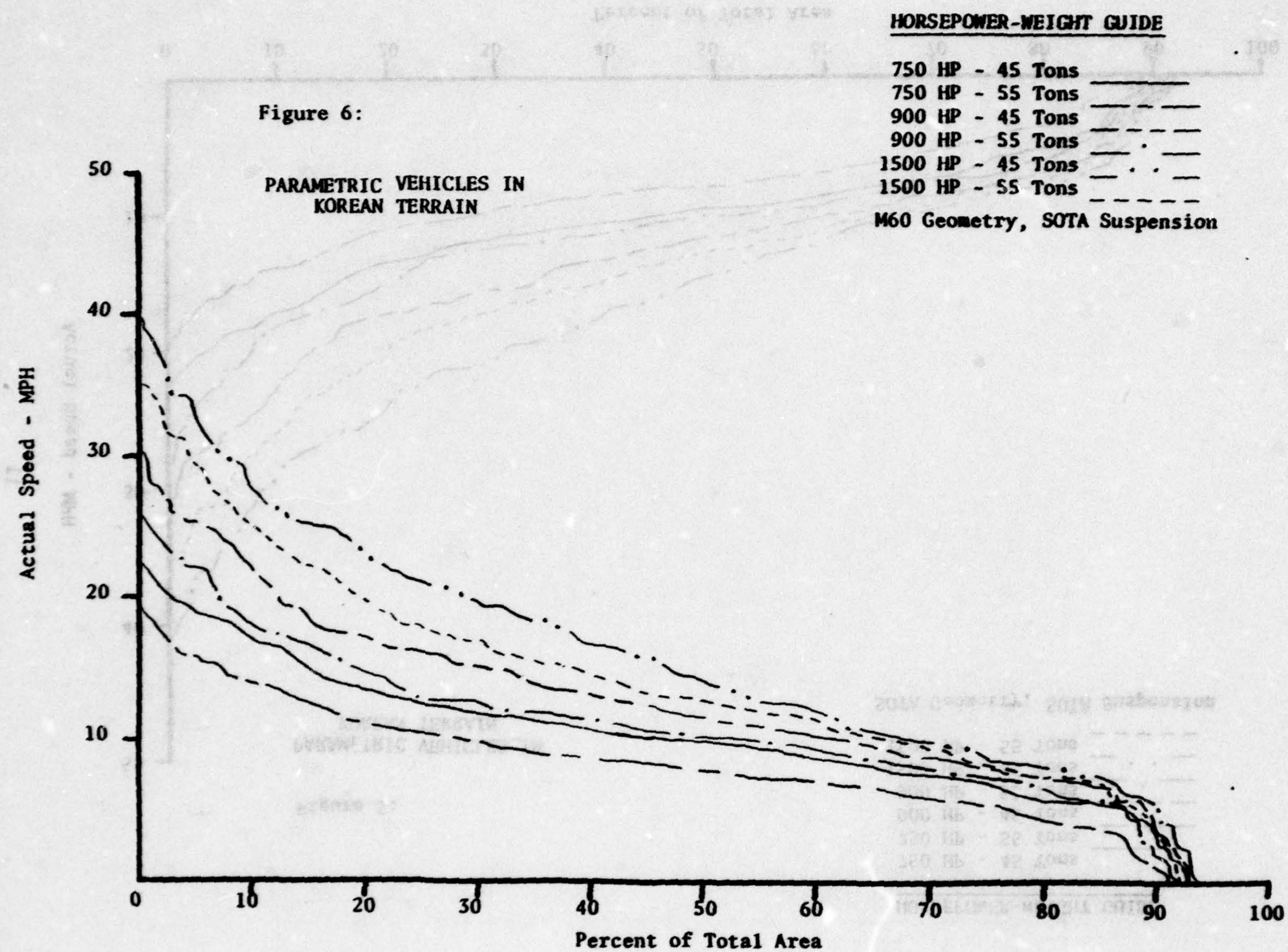
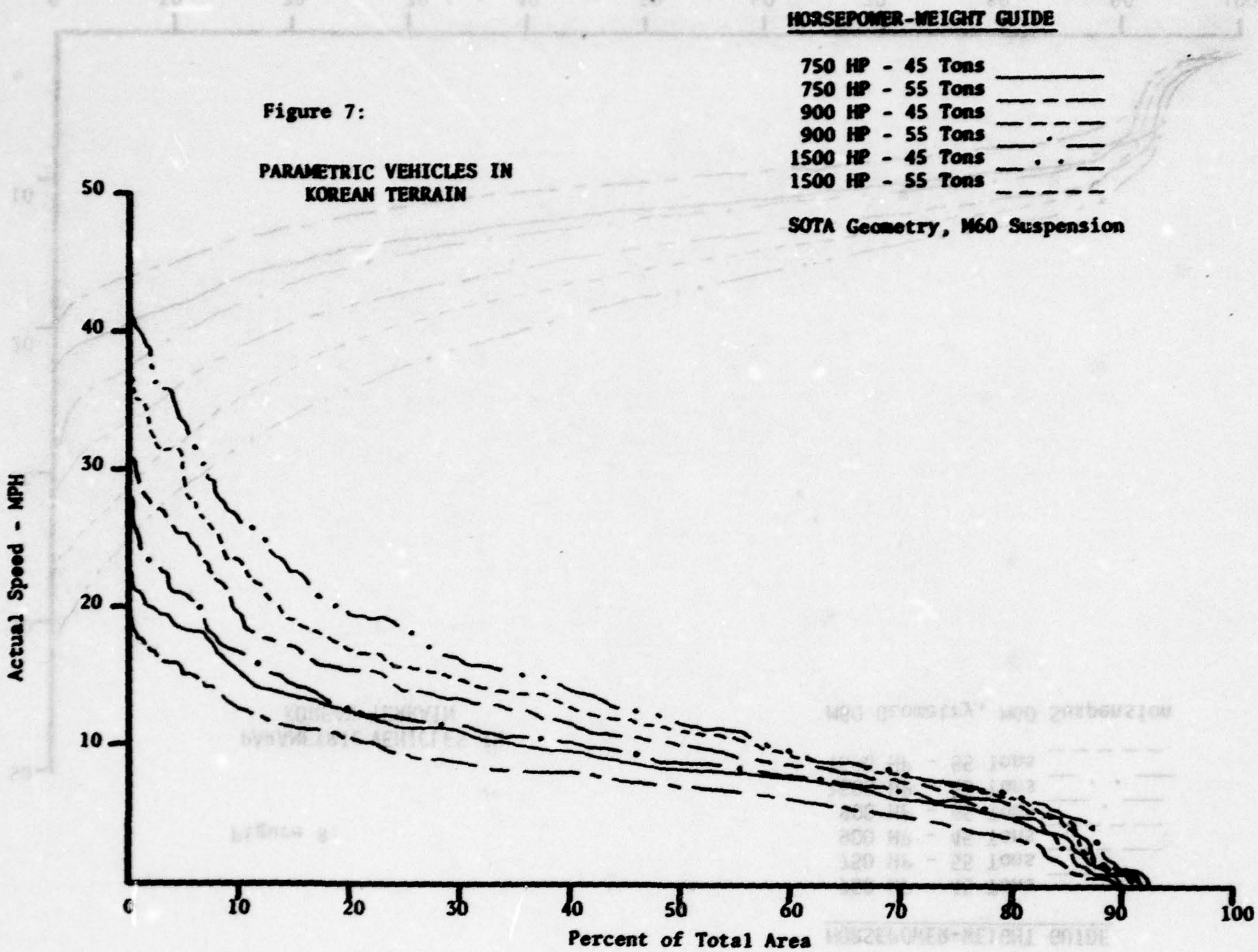


Figure 6:

PARAMETRIC VEHICLES IN KOREAN TERRAIN

Figure 7:

PARAMETRIC VEHICLES IN KOREAN TERRAIN



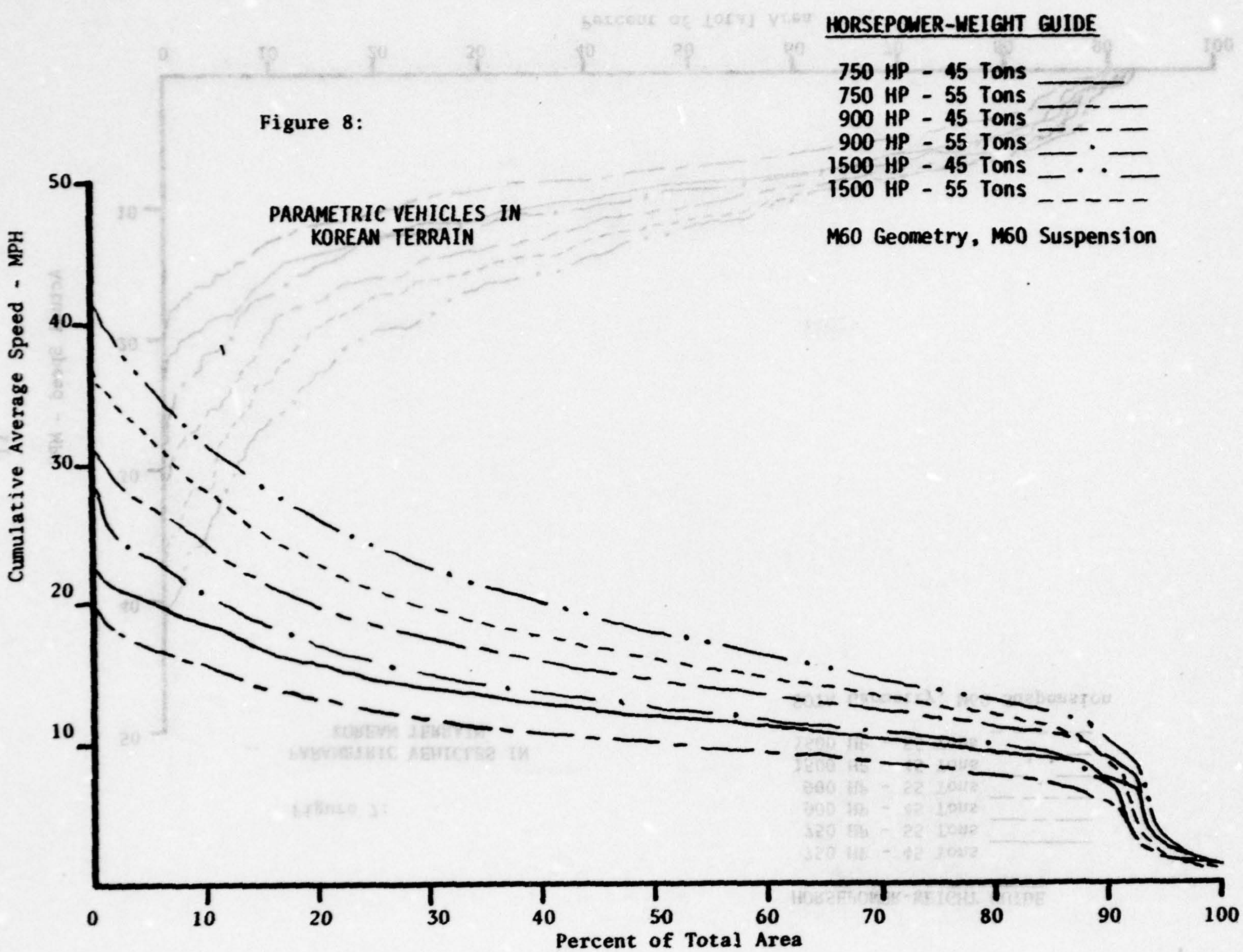


Figure 8:

PARAMETRIC VEHICLES IN KOREAN TERRAIN

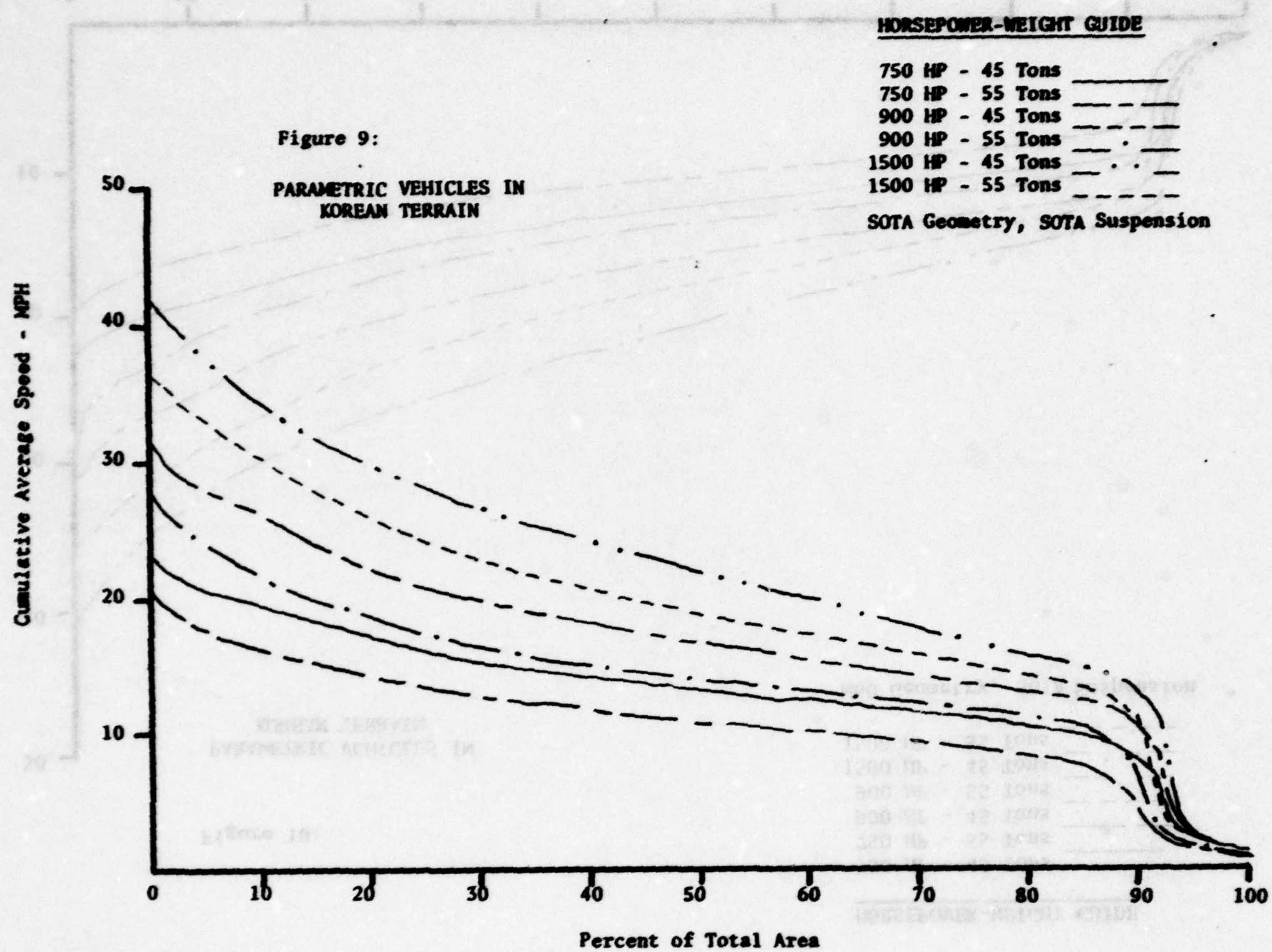
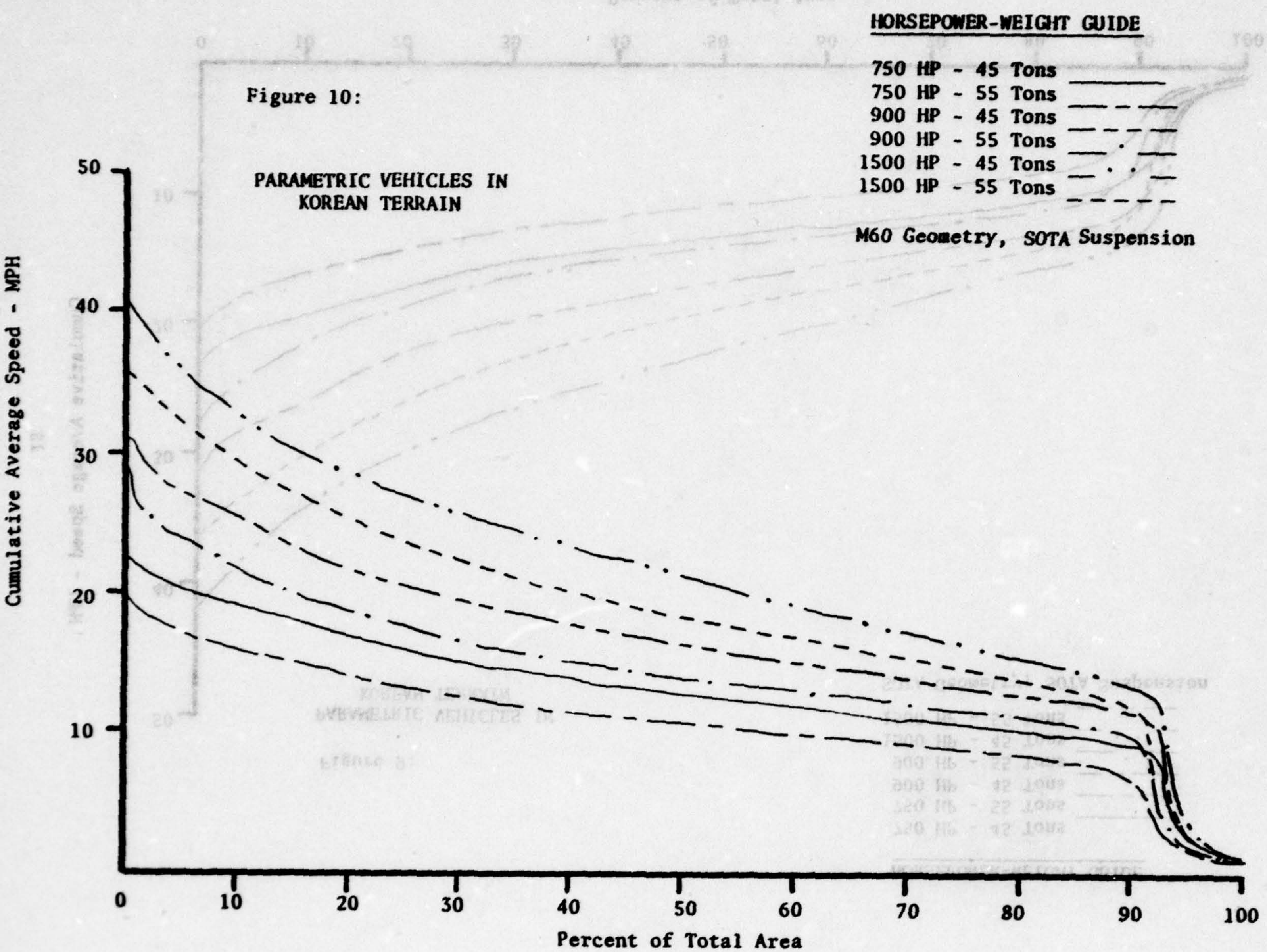


Figure 9:

PARAMETRIC VEHICLES IN
KOREAN TERRAIN

Figure 10:

PARAMETRIC VEHICLES IN KOREAN TERRAIN



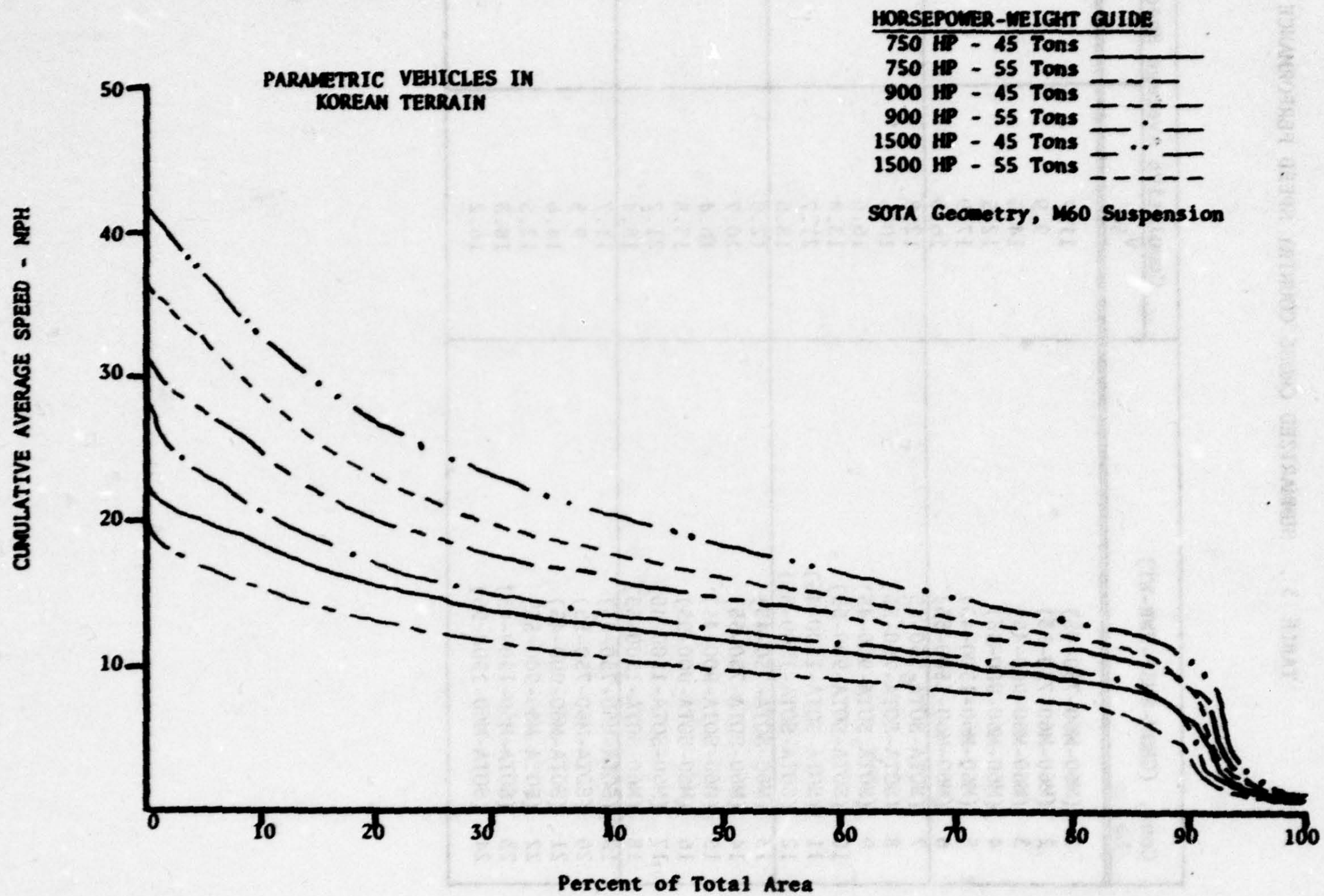


Figure 11:

PARAMETRIC VEHICLES IN KOREAN TERRAIN

TABLE 3 . SUMMARIZED CROSS COUNTRY SPEED PERFORMANCE

Conf. No.	(GEOM-SUSP-PWR-WT)	Cumulative Average Speed (MPH)	
		V_{50}	V_{80}
1	(M60-M60-750-45)	11.7	9.2
2	(M60-M60-750-55)	9.9	7.5
3	(M60-M60-900-45)	14.5	11.1
4	(M60-M60-900-55)	12.5	9.[illegible]
5	(M60-M60-1500-45)	17.9	12.9
6	(M60-M60-1500-55)	16.0	11.9
7	(SOTA-SOTA-750-45	12.8	10.2
8	(SOTA-SOTA-750-55)	10.6	8.1
9	(SOTA-SOTA-900-45)	16.6	12.8
10	(SOTA-SOTA-900-55)	13.8	11.0
11	(SOTA-SOTA-1500-45)	21.7	15.6
12	(SOTA-SOTA-1500-55)	18.6	14.1
13	(M60-SOTA-750-45)	12.9	10.3
14	(M60-SOTA-750-55)	10.7	8.5
15	(M60-SOTA-900-45)	16.4	12.8
16	(M60-SOTA-900-55)	13.8	11.1
17	(M60-SOTA-1500-45)	21.2	15.4
18	(M60-SOTA-1500-55)	18.4	13.8
19	(SOTA-M60-750-45)	11.7	9.1
20	(SOTA-M60-750-55)	9.8	7.4
21	(SOTA-M60-900-45)	14.6	11.1
22	(SOTA-M60-900-55)	12.5	9.7
23	(SOTA-M60-1500-45)	18.3	13.0
24	(SOTA-M60-1500-55)	16.2	12.0

TABLE 4. AVERAGE PERFORMANCE IMPROVEMENTS OBTAINED FROM VEHICLE COMPONENT VARIATION

Component	Variation	Improvement V_{50}	Improvement V_{80}
• Suspension	M60 → SOTA	12.5%	14.7%
• Power Train			
	750 HP → 900 HP	27.3%	27.6%
	900 HP → 1500 HP	29.3%	21.6%
• Hull Geometry	M60 → SOTA	0.5%	-0.4%
• Weight	55T → 45T	17.3%	15.9%

TABLE 5 Frequency of Limiting Factor Occurrence

CONF NO.	(GEOM-SUSP-PWR-WT)	LIMITING FACTOR NUMBER 1	2	3	4	5	6	7	8	9	10
1	(M60- M60- 750-45)	2.7	0.4	1.0	2.9	17.7	9.1	3.1	15.7	24.9	22.5
2	(M60- M60- 750-55)	4.5	0.1	0.8	3.0	15.8	9.9	2.7	15.3	27.4	20.7
3	(M60- M60- 900-45)	2.7	0.4	1.0	2.9	16.8	9.3	8.0	15.9	18.9	24.1
4	(M60- M60- 900-55)	4.5	0.1	1.0	2.9	15.8	9.4	6.6	15.8	21.7	22.2
5	(M60- M60-1500-45)	2.7	0.4	0.6	2.9	20.3	5.6	12.2	18.1	12.0	25.3
6	(M60- M60-1500-55)	4.5	0.1	0.6	3.0	19.2	7.1	10.0	16.9	15.2	23.7
7	(SOTA-SOTA-750-45)	3.1	0.1	2.2	2.9	8.6	13.6	3.1	16.9	34.9	14.7
8	(SOTA-SOTA-750-55)	4.6	0.0	2.8	2.9	7.9	14.4	2.5	16.1	36.0	12.9
9	(SOTA-SOTA-900-45)	3.1	0.1	1.7	2.9	11.2	11.1	10.0	17.2	26.5	16.3
10	(SOTA-SOTA-900-55)	4.6	0.0	2.2	2.9	9.9	11.3	8.1	16.6	29.9	14.7
11	(SOTA-SOTA-1500-45)	3.1	0.1	1.2	2.9	16.1	8.5	14.0	17.5	19.0	17.7
12	(SOTA-SOTA-1500-55)	4.6	0.0	1.3	2.9	14.7	9.0	11.8	17.8	20.9	17.1
13	(M60- SOTA-750-45)	2.7	0.4	0.8	2.9	8.4	12.4	5.4	13.7	34.3	19.1
14	(M60- SOTA-750-55)	4.5	0.1	0.8	3.0	7.8	12.9	4.6	12.5	36.1	17.8
15	(M60- SOTA-900-45)	2.7	0.4	0.7	2.9	10.7	9.7	13.4	14.0	25.2	20.3
16	(M60- SOTA-900-55)	4.5	0.1	0.8	2.9	9.6	9.8	10.9	13.7	28.8	19.1
17	(M60- SOTA-1500-45)	2.7	0.4	0.4	2.9	14.1	6.4	19.3	15.0	15.9	23.0
18	(M60- SOTA-1500-55)	4.5	0.1	0.4	3.0	13.3	7.6	16.0	14.9	19.2	21.2
19	(SOTA-M60- 750-45)	3.1	0.1	2.4	2.9	18.6	9.2	1.8	17.9	25.0	19.0
20	(SOTA-M60- 750-55)	4.6	0.0	2.8	2.9	16.6	10.4	1.3	17.5	27.2	16.8
21	(SOTA-M60- 900-45)	3.1	0.1	2.0	2.9	17.1	10.5	5.9	17.9	20.7	20.0
22	(SCTA-M60- 900-55)	4.6	0.0	2.4	2.9	15.9	10.8	4.9	17.4	22.2	19.0
23	(SOTA-M60-1500-45)	3.1	0.1	1.4	2.9	21.8	7.5	8.2	20.0	13.6	21.5
24	(SOYA-M60-1500-55)	4.6	0.0	1.5	2.9	20.2	8.4	6.8	18.9	16.1	20.5

NOTE: Table values are percent of total area for which factor constrains mobility

7. Visibility

8. Maneuvering (through vegetation and obstacles)

9. Total resistance to movement (including vegetation and obstacle override).

10. Acceleration and deceleration between obstacles.

Table 5 indicates the percentage of the total terrain area for which each of the 10 factors was the operative constraint, for each vehicle configuration. For example, if one were interested in power train effects on speed, configurations 8 and 12 might be compared. Speed limiting factors numbered 6 and 9 deal with power train constraints, and by summing these frequencies together we see that an increase from 750 HP to 1500 HP decreases the area in which we are power train limited from 50.4% of the total area to 29.9%. (Power effects are present in some of the other limiting factors, but 6 and 9 are the key factors.) It should be noted that this table only indicates the frequency with which the various factors are constraining, but not the performance level at which the constraint occurs.

6. SOFT SOIL MOBILITY CONSIDERATIONS

In addition to the comprehensive analysis of cross-country mobility provided in the previous section, there is also an issue of vehicle performance in marginal soft soil to be addressed. The primary design parameters involved in marginal soft soil performance are the length and width of the track, the contact area of the track shoe, and the weight of the vehicle. Again the analysis was conducted with a high and a lower level assigned to each of these factors so that the relative contribution of each might be identified. Table 6 identifies the levels selected for analysis of the track variables. It also shows the nominal ground pressure associated with each combination of variables at the two previously selected gross vehicle weights. Finally, the table shows a VCI_1 and VCI_{50} entry for each configuration. This is the minimum soil strength as measured by cone penetrometer readings which will permit one and fifty passes respectively, of the vehicle through the soil. The equations for calculating vehicle cone index (VCI) numbers have been empirically derived and are shown in Appendix B.

There is no direct relationship between vehicle cone index and ground pressure. However, over the relatively small variation in track parameters considered here, reasonably linear relationships can be established, as shown in Figure 12. The data points are those from Table 6. These trend lines provide a gross estimate of the soil strength required to support a vehicle with a given ground pressure.

In order to assess the significance of differences in ground pressure over the range analyzed (from about 9 psi to about 14 psi) it is necessary

Table 6 **MARGINAL SOFT SOIL MOBILITY FACTORS**

TRACK LENGTH (IN.)	TRACK WIDTH (IN.)	SHOE AREA $(IN.)^2$	45 TONS NOM. GRD PRESS. (PSI)	45 TONS VCI_1	45 TONS VCI_{50}	55 TONS NOM. GRD. PRESS. (PSI)	55 TONS VCI_1	55 TONS VCI_{50}
160	24	160	11.7	20.7	48.3	14.3	28.9	66.1
160	24	180	11.7	20.6	48.0	14.3	28.8	65.8
160	28	160	10.0	17.0	40.0	12.2	23.1	53.5
160	28	180	10.0	16.8	39.8	12.2	23.0	53.2
180	24	160	10.4	19.2	44.9	12.7	26.5	60.8
180	24	180	10.4	19.1	44.6	12.7	26.4	60.5
180	28	160	8.9	15.8	37.4	10.9	21.3	49.6
180	28	180	8.9	15.7	37.2	10.9	21.2	49.3

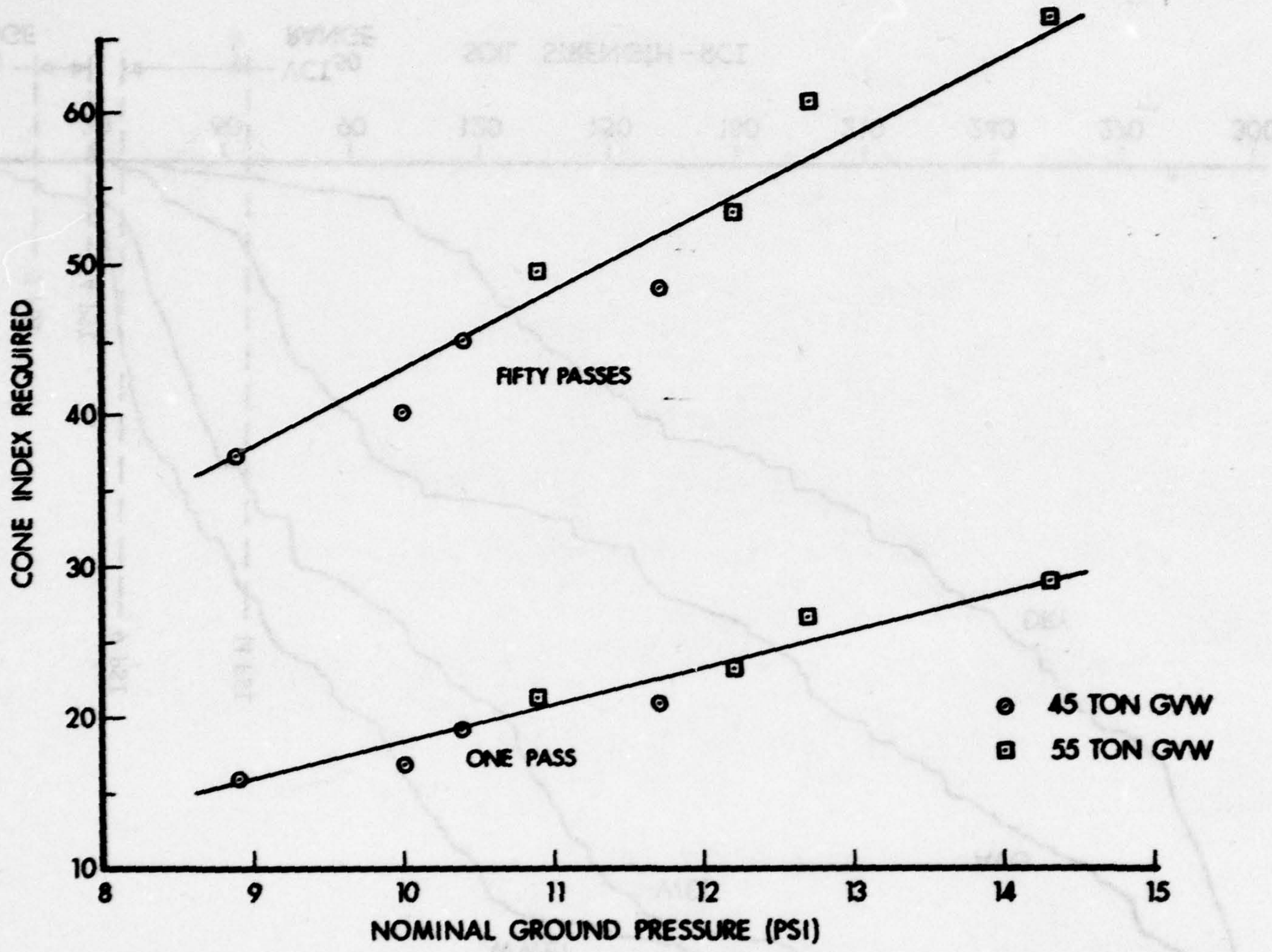


Figure 12. Gross Relationship Between Vehicle Ground Pressure and Soil Strength Required for Mobility

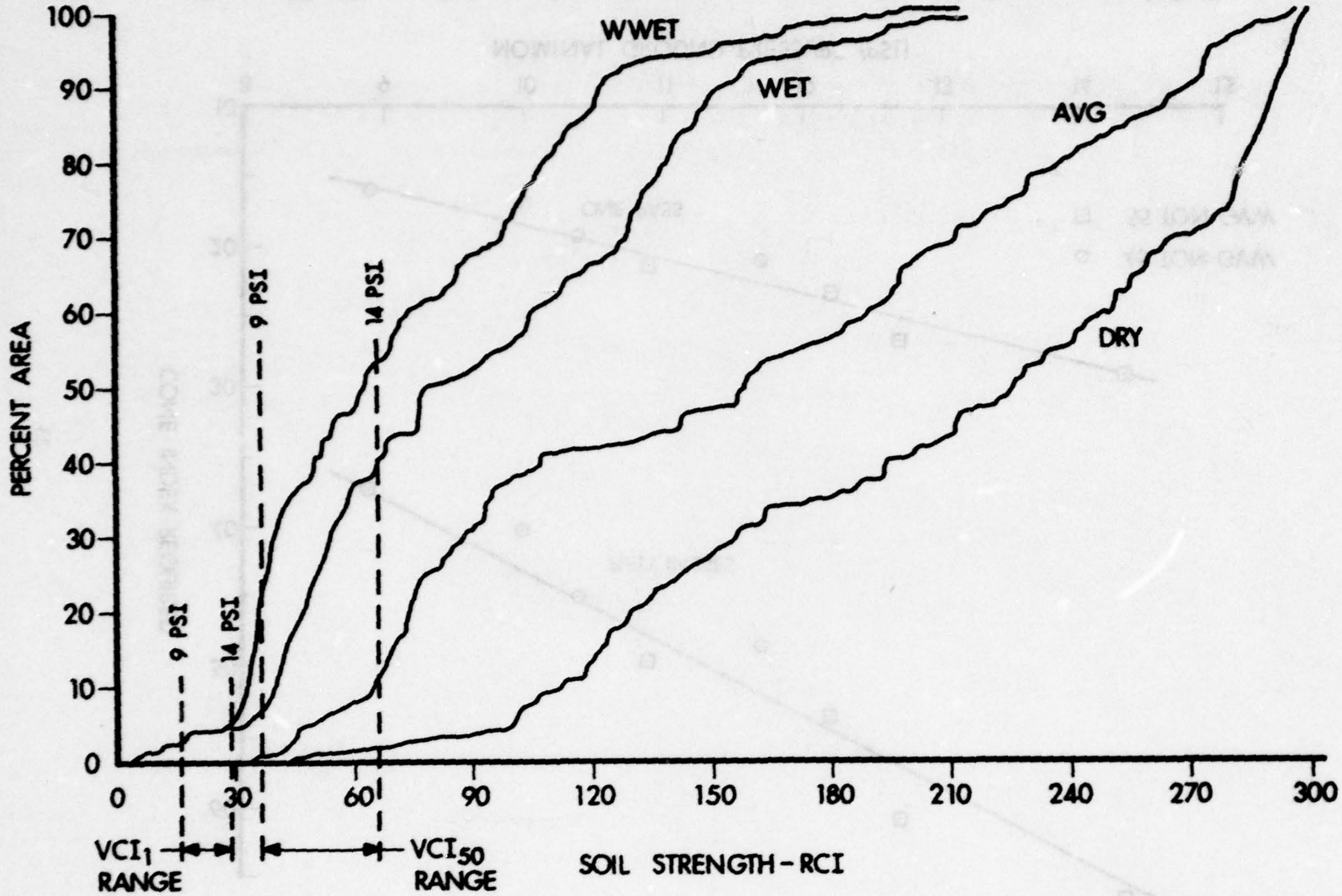


Figure 13. Soft Soil Limitation in Korean Terrain.

to determine the frequency with which soil strengths in the Korean terrain are sufficiently low as to influence vehicle passage. Figure 13 shows the cumulative frequency distributions of soil strengths for various seasons. The wet season and dry season distributions are obtained by referring to yearly average rainfall data and selecting the wettest and driest 30 day periods for analysis. The average season reflects soil conditions over the remaining 305 days. The fourth distribution (referred to as "WWET") is an estimate of conditions in severe periods of rainfall. It reflects the soil strength conditions over the 10 wettest days of the year but with the yearly averages for those days increased by 50 percent, as might be experienced in a particularly wet year.

Superimposed on the distribution curves in Figure 13 are the soil strengths required for both one and 50 vehicle passes at 9 and 14 PSI ground pressure. It may be observed that the significance of ground pressure is minimal insofar as the probability of completing one vehicle pass through Korean soft soil is concerned under any seasonal condition. However, the probability that the soil will support repeated traffic is very much affected by ground pressure. For example, in the wet season, about eight percent of the terrain will not support 50 passes of vehicles with 9 PSI ground pressure while 40% of the terrain will not support 50 passes if the vehicle ground pressure is 14 PSI.

7. CONCLUSIONS

Keeping in mind that the results of the preceding section have been derived from analysis in the sample Korean terrain only, and assuming the parameter ranges used represent the feasible alternatives, the following conclusions are offered:

o Power train selection has the most critical impact on mobility potential. However, it is a case of diminishing returns. A relatively small increase from 750 HP to 900 HP produces about the same percentage improvement as does the much larger step in going from 900 HP to 1500 HP. (In both cases the absolute improvement in V_{80} is about 2.4 MPH.)

o The next best place to look for improved mobility is probably the suspension. Over the ranges considered the weight has a slightly greater effect, but weight reduction may mean a tradeoff in protection level. A suspension improvement produces about the same effect on mobility, but is more readily achieved.

o Movement rate is shown to be insensitive to hull geometry, however, lack of attention to this design factor can result in serious obstacle interference problems.

o Based on the above conclusions and using V_{80} as an index of mobility performance, Figure 14 shows the incremental improvements afforded by component changes ordered according to their payoff.

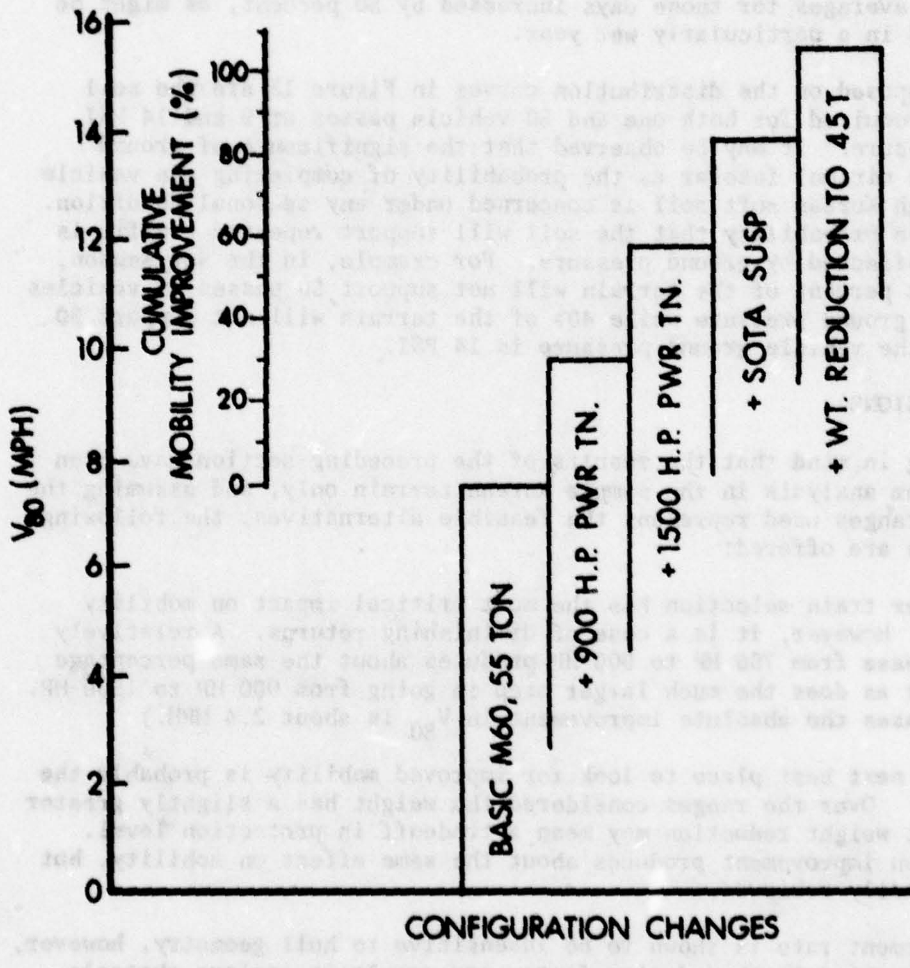


Figure 14. Mobility Enhancement Provided by Configuration Changes.

o Finally, with regard to soft soil mobility, it appears that the criticality of the track configuration is very dependent on gross vehicle weight. A 45-ton vehicle will have few trafficability problems with most of the track configurations. For areas of repeated traffic, it is desirable to maintain a ground pressure of 11 PSI or less. For a 55-ton vehicle the acceptable track configurations are thus narrowed considerably.

Next page is blank.

APPENDIX A

<u>TERRAIN FACTOR DISTRIBUTIONS</u>

Next page is blank.

FIGURE A.1

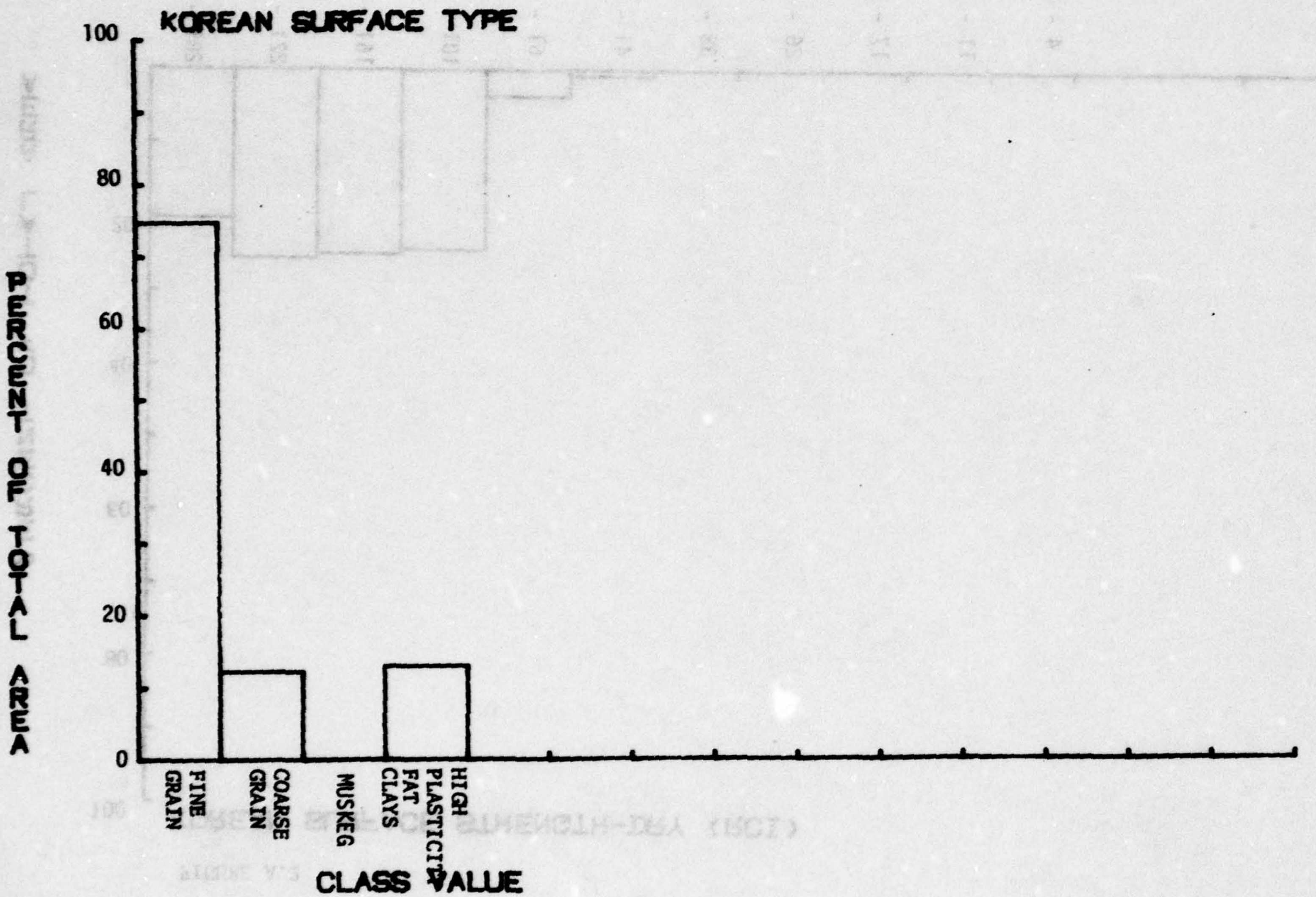

KOREAN SURFACE TYPE
PERCENT OF TOTAL AREA
100
80
60
40
20
0
FINE GRAIN
COARSE GRAIN
MUSKEG
HIGH PLASTICITY FAT CLAYS
CLASS VALUE

FIGURE A.2

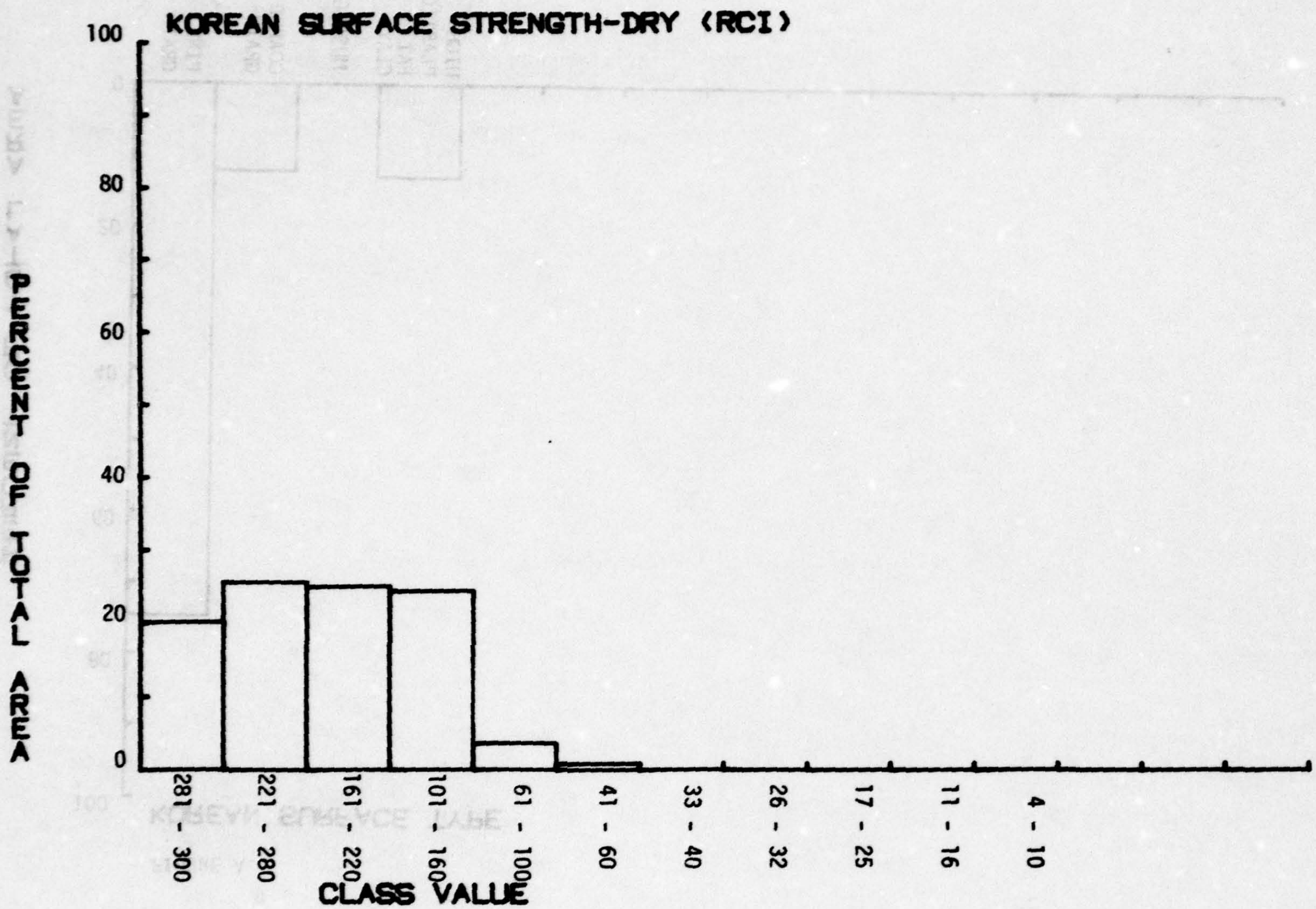

KOREAN SURFACE STRENGTH-DRY (RCI)
PERCENT OF TOTAL AREA
100
80
60
40
20
0
281 - 300
221 - 280
161 - 220
101 - 160
61 - 100
41 - 60
33 - 40
26 - 32
17 - 25
11 - 16
4 - 10
CLASS VALUE

FIGURE A.3

KOREAN SURFACE STRENGTH-AVERAGE (RCI)

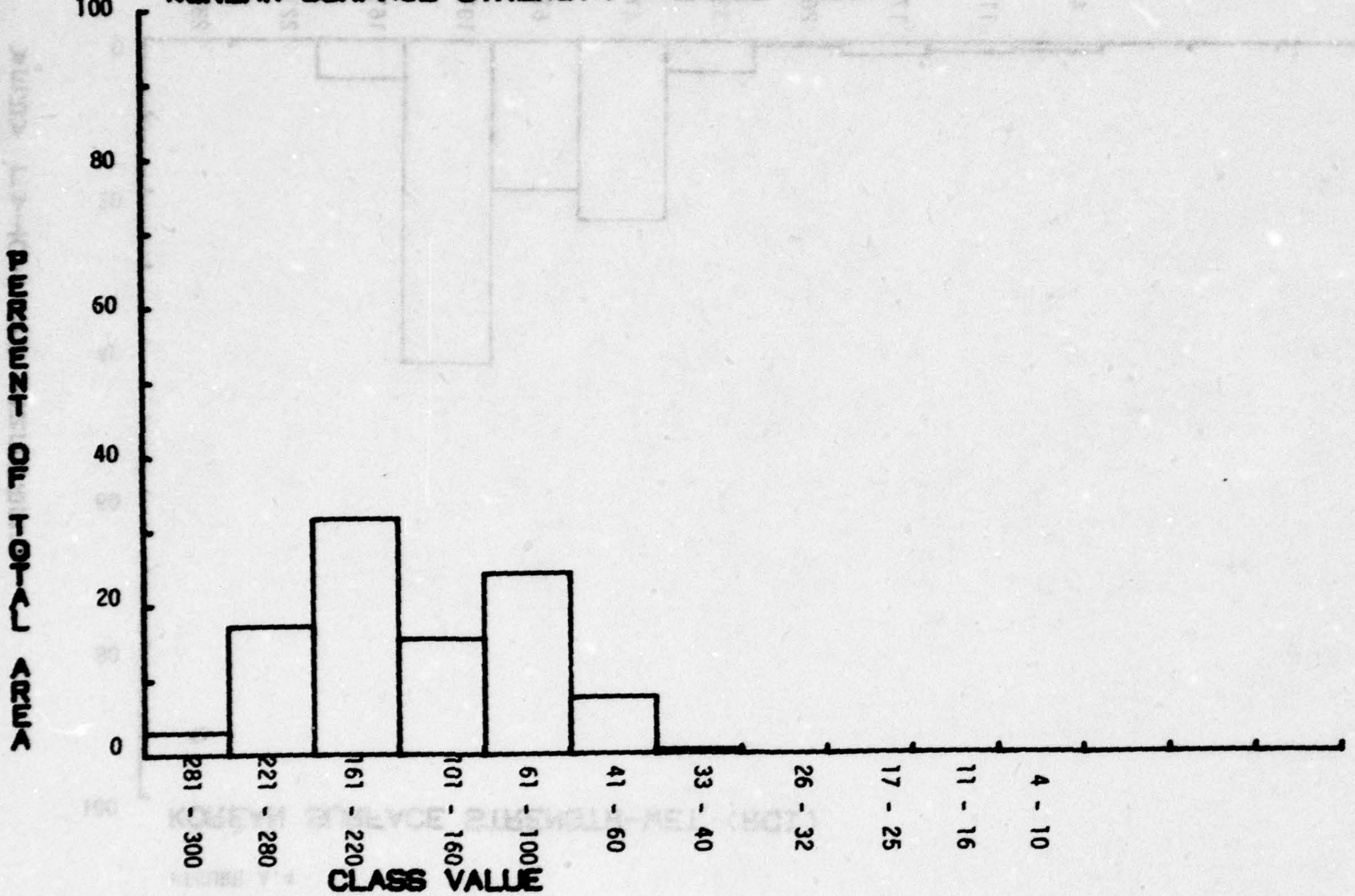


FIGURE A.4

KOREAN SURFACE STRENGTH-WET (RCI)

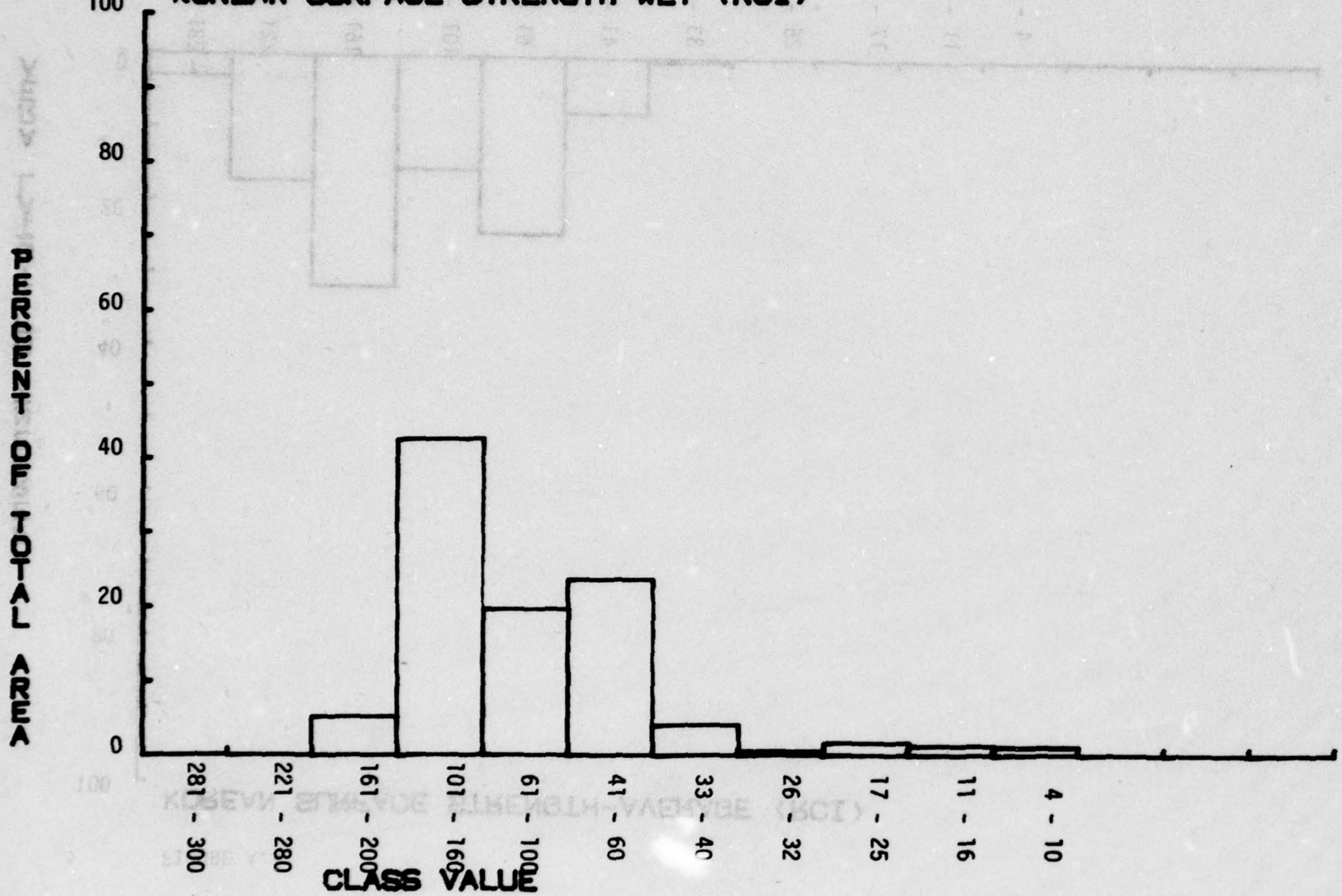


FIGURE A-5

KOREAN SURFACE STRENGTH-WETWET (RCI)

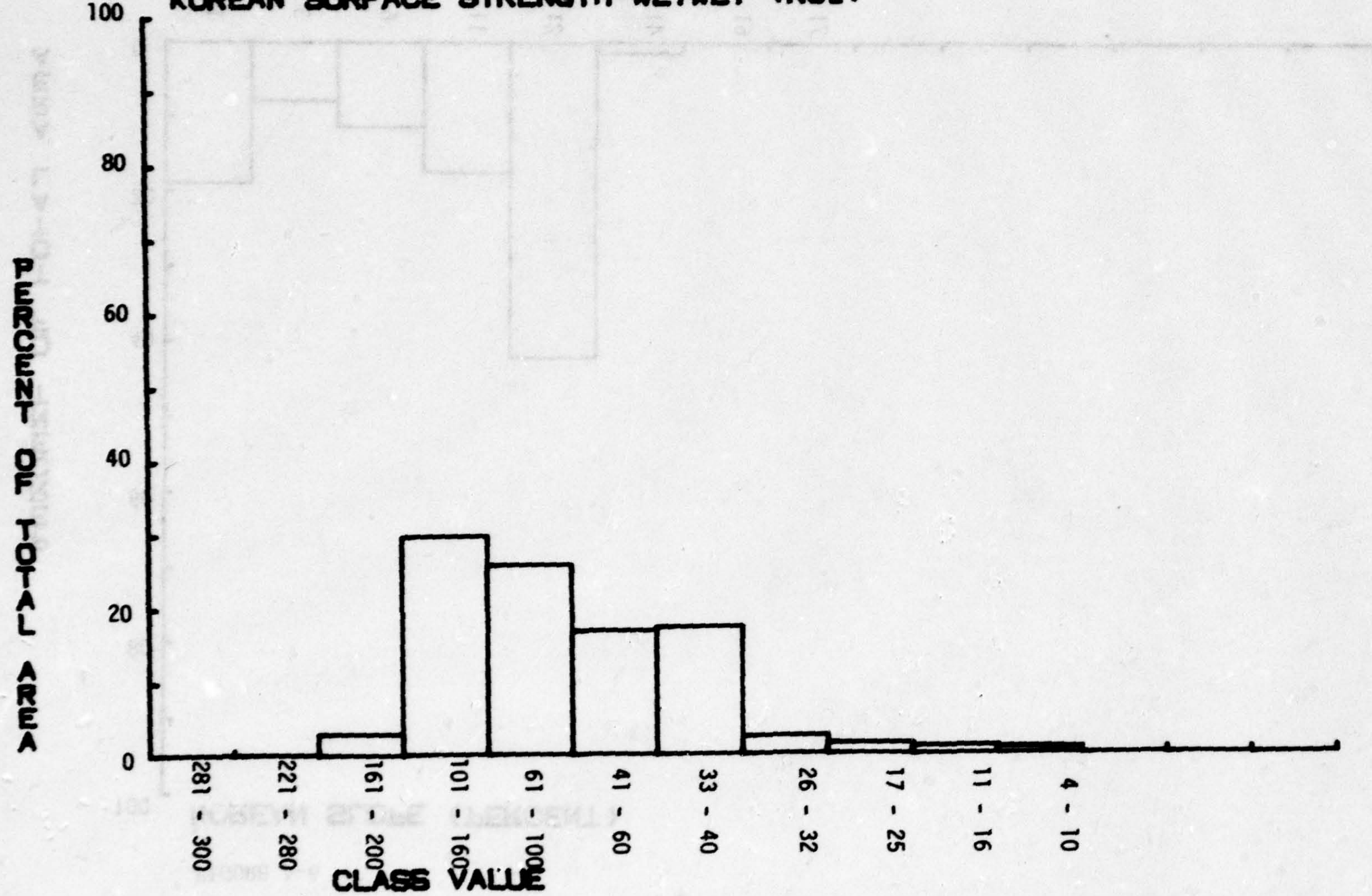
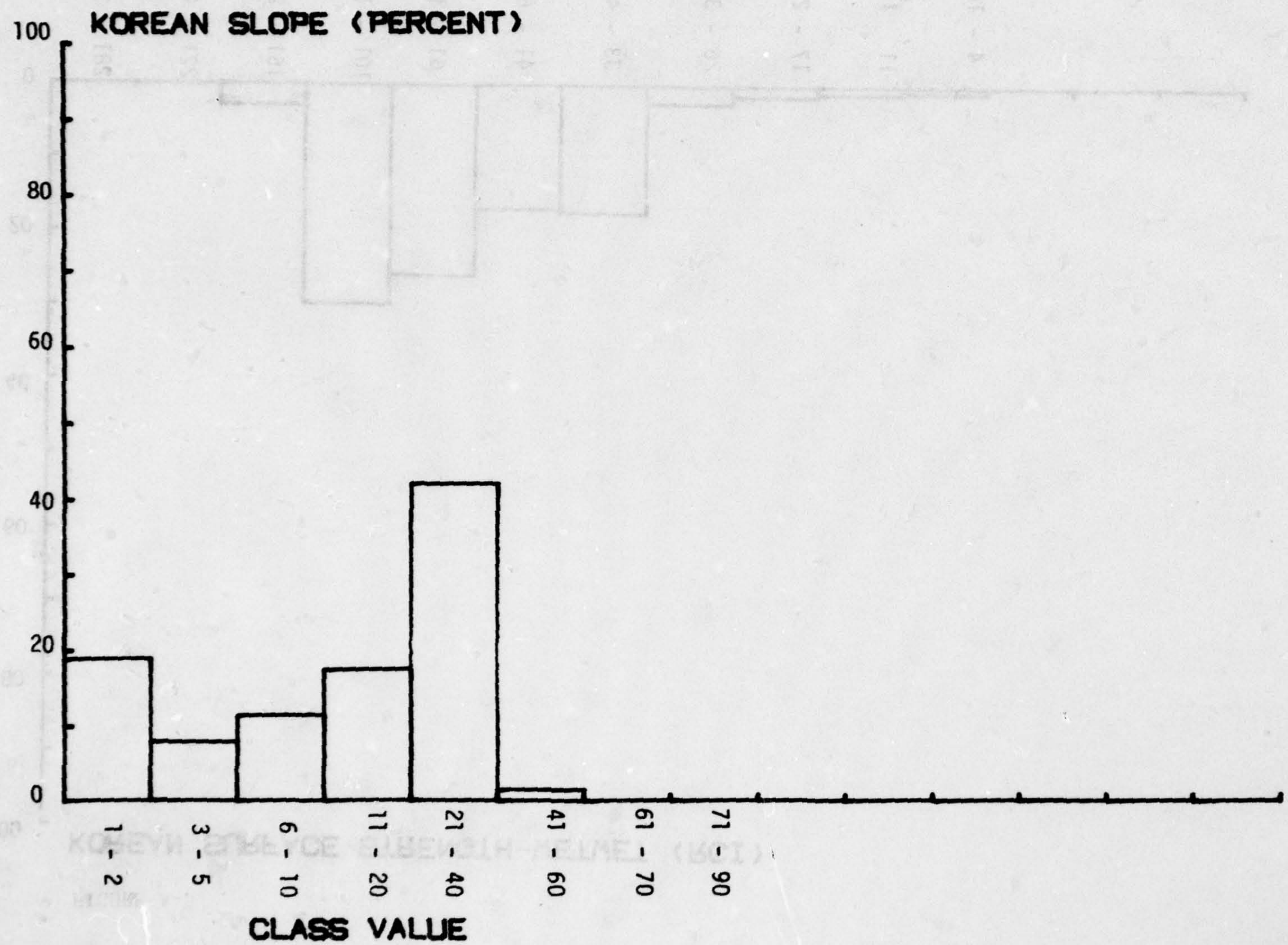


FIGURE A-6



KOREAN SLOPE (PERCENT)
PERCENT OF TOTAL AREA
100
80
60
40
20
0
1 - 2
3 - 5
6 - 10
11 - 20
21 - 40
41 - 60
61 - 70
71 - 90
CLASS VALUE

FIGURE A-7

KOREAN OBSTACLE APPROACH ANGLES (DEGREES)

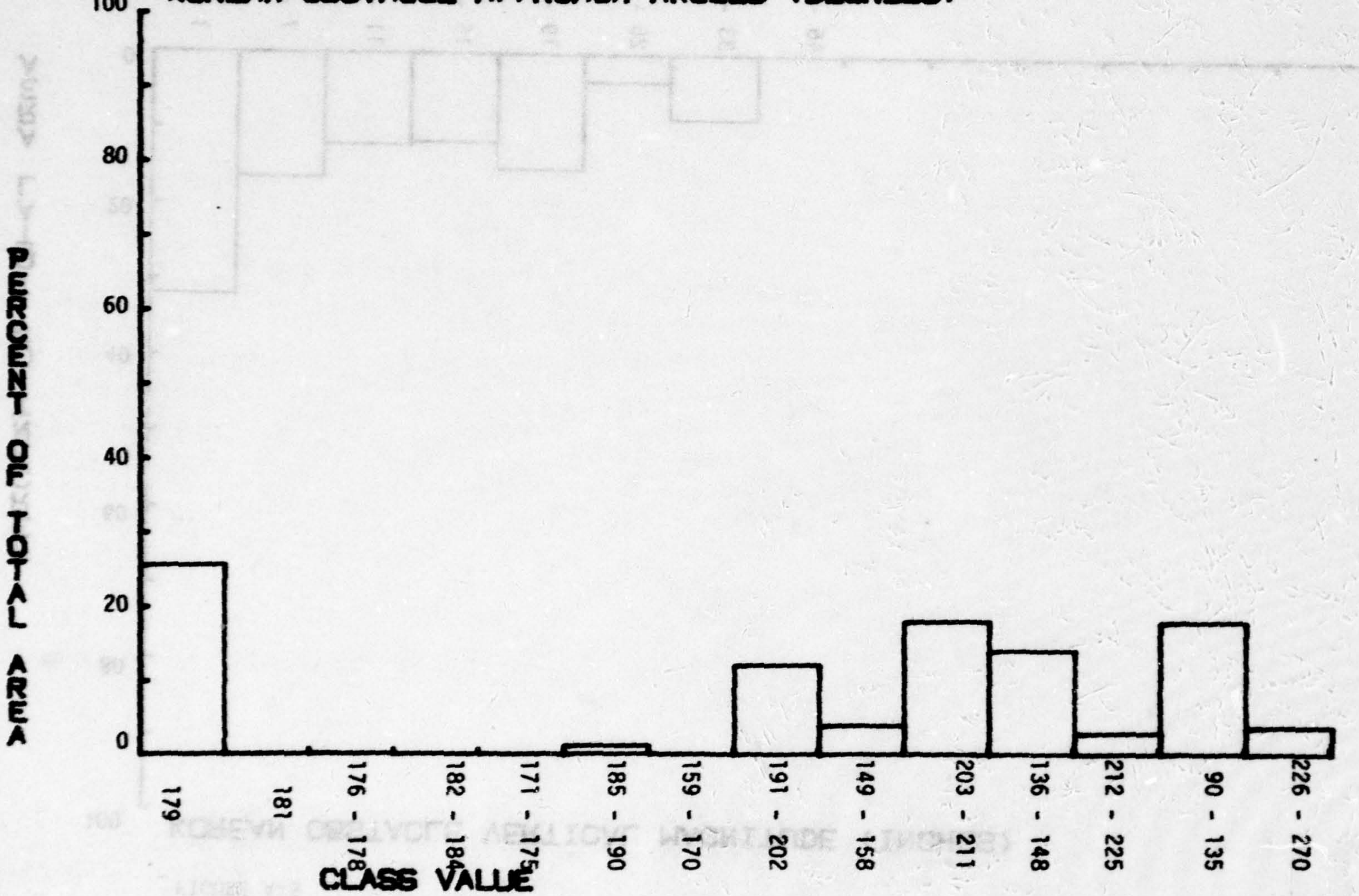


FIGURE A-8

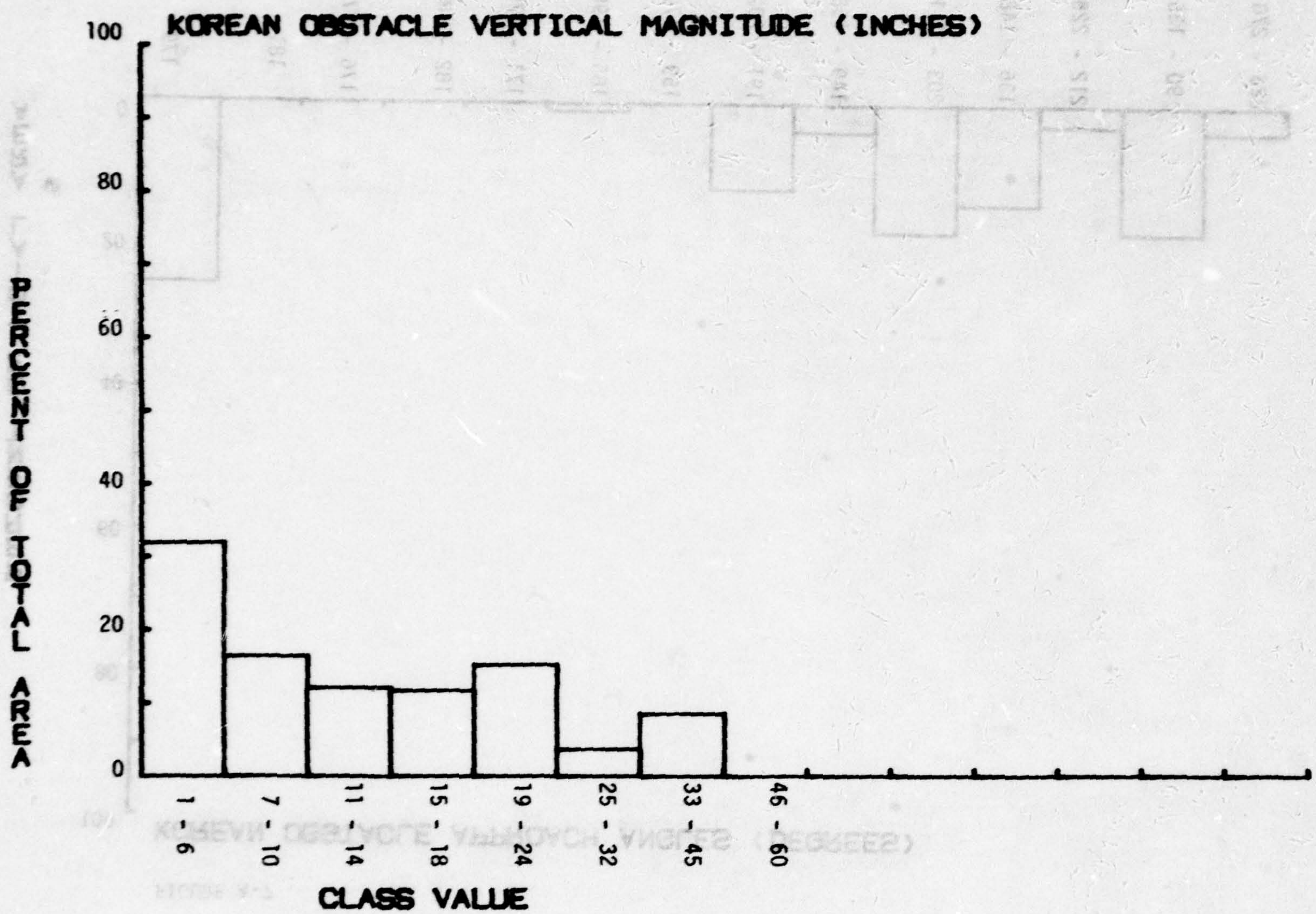

KOREAN OBSTACLE VERTICAL MAGNITUDE (INCHES)
PERCENT OF TOTAL AREA
100
80
60
40
20
0
1 - 6
7 - 10
11 - 14
15 - 18
19 - 24
25 - 32
33 - 45
46 - 60
CLASS VALUE

FIGURE A-9

KOREAN OBSTACLE BASE WIDTHS (INCHES)

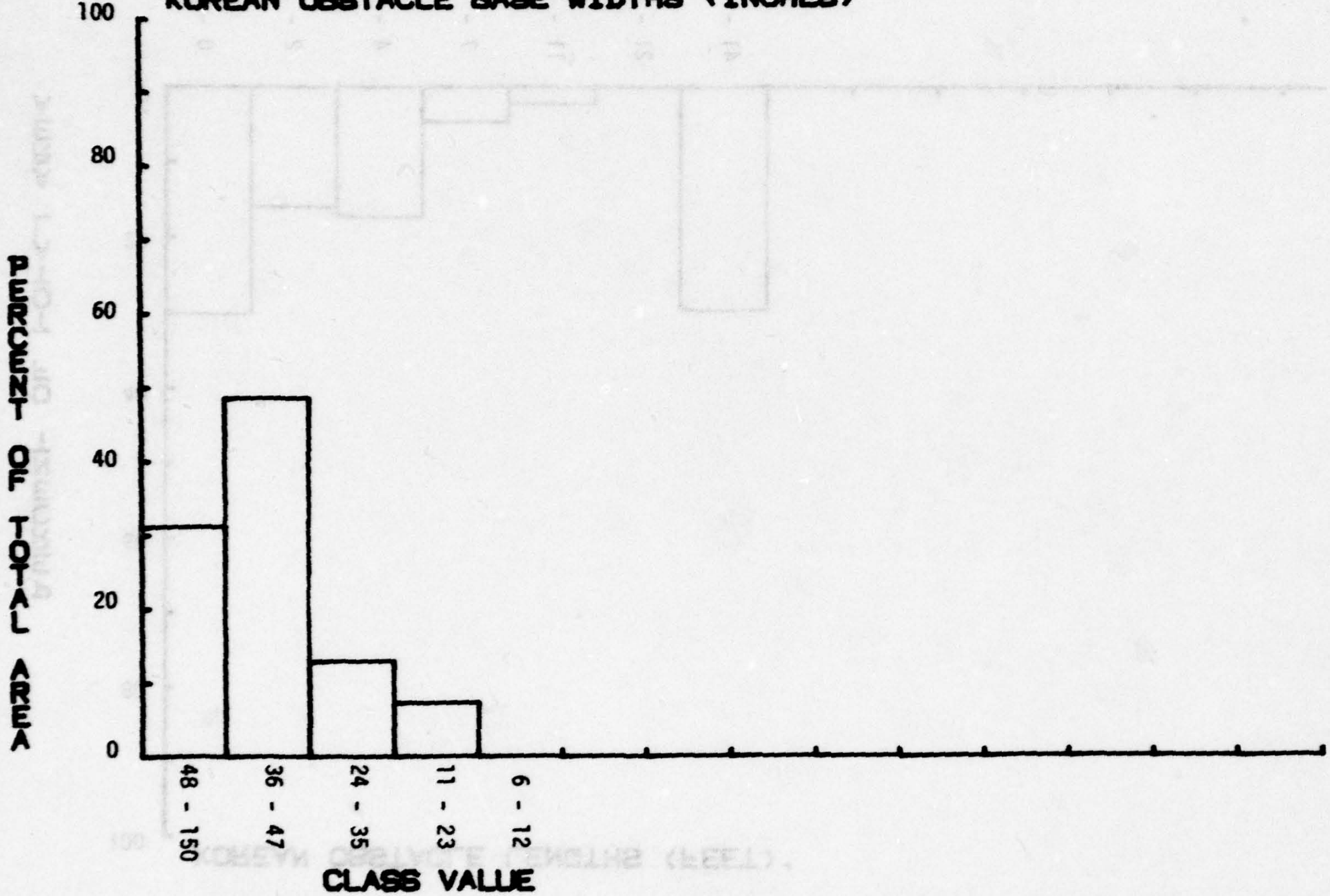


FIGURE A-10

KOREAN OBSTACLE LENGTHS (FEET)'

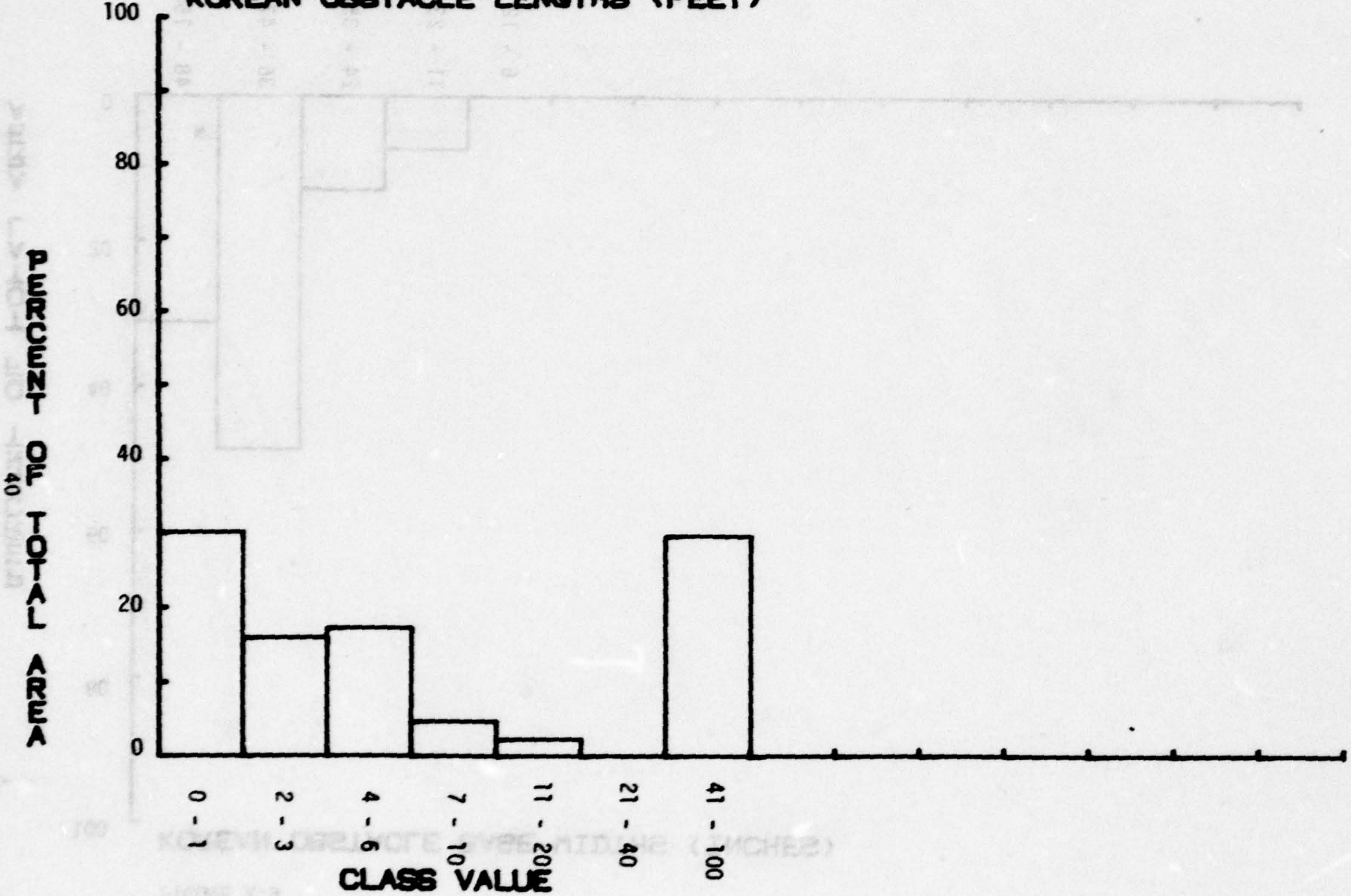


FIGURE A-11

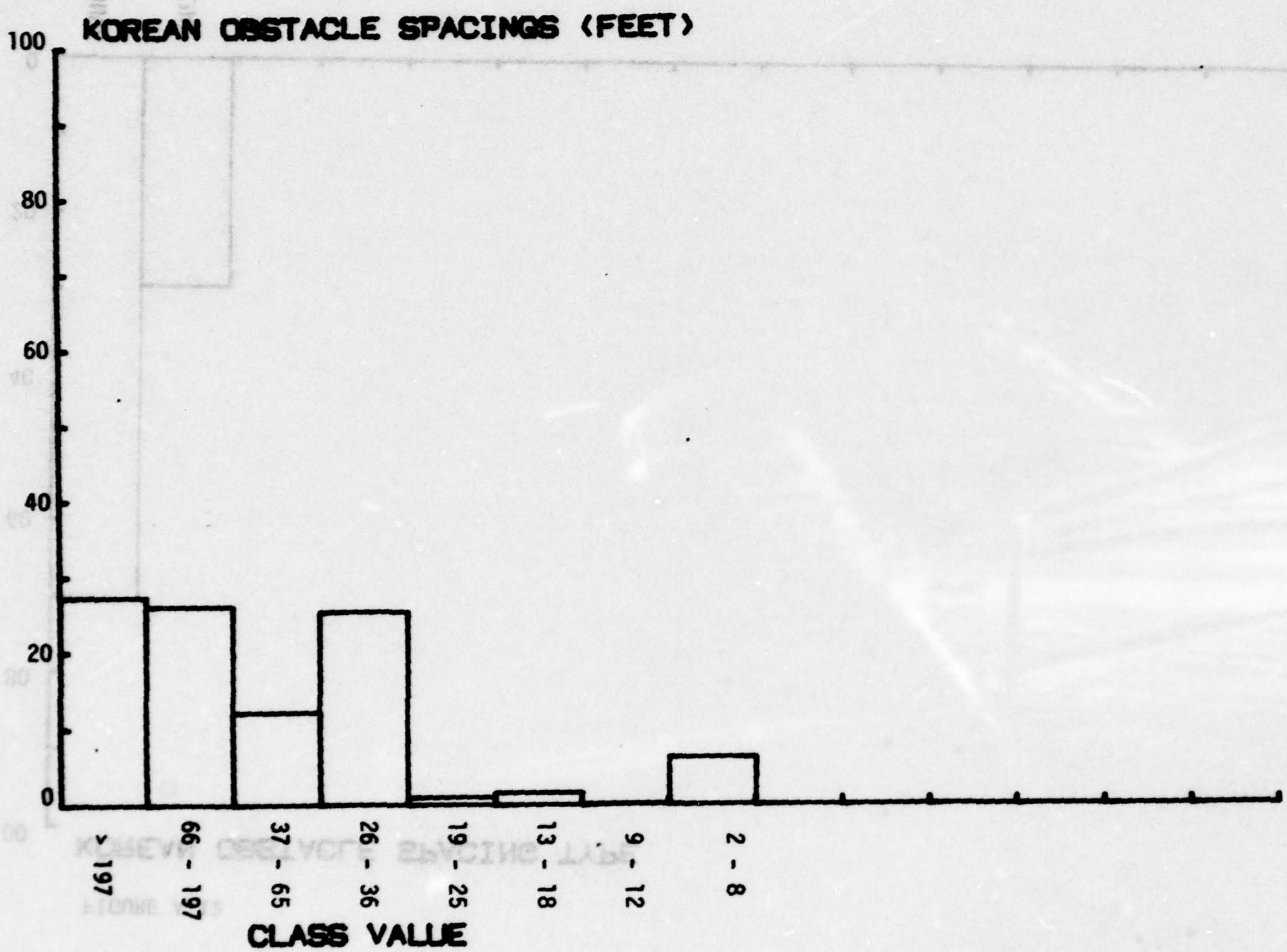

KOREAN OBSTACLE SPACINGS (FEET)
PERCENT OF TOTAL AREA
100
80
60
40
20
0
> 197
66 - 197
37 - 65
26 - 36
19 - 25
13 - 18
9 - 12
2 - 8
CLASS VALUE

FIGURE A-12

KOREAN OBSTACLE SPACING TYPE

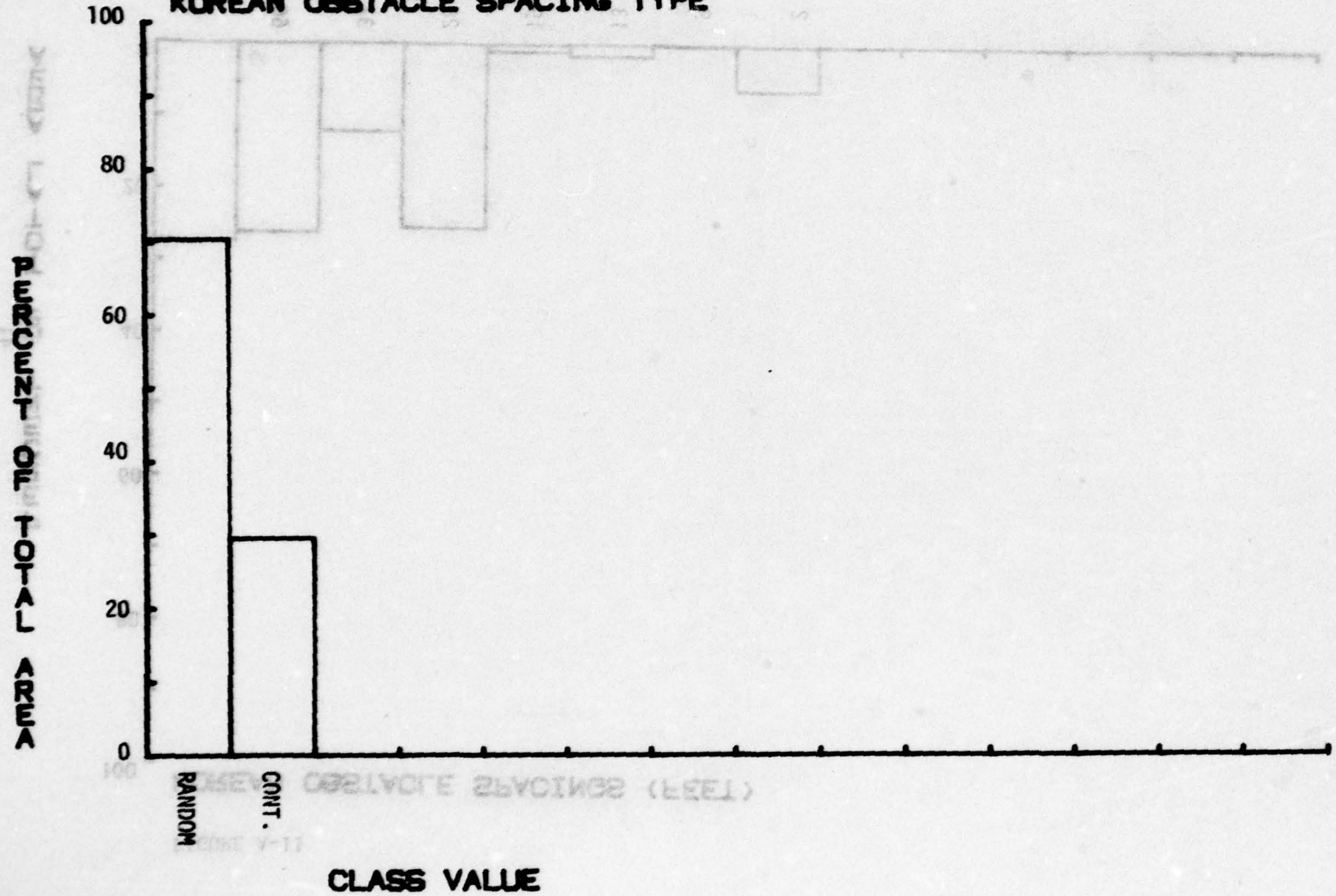
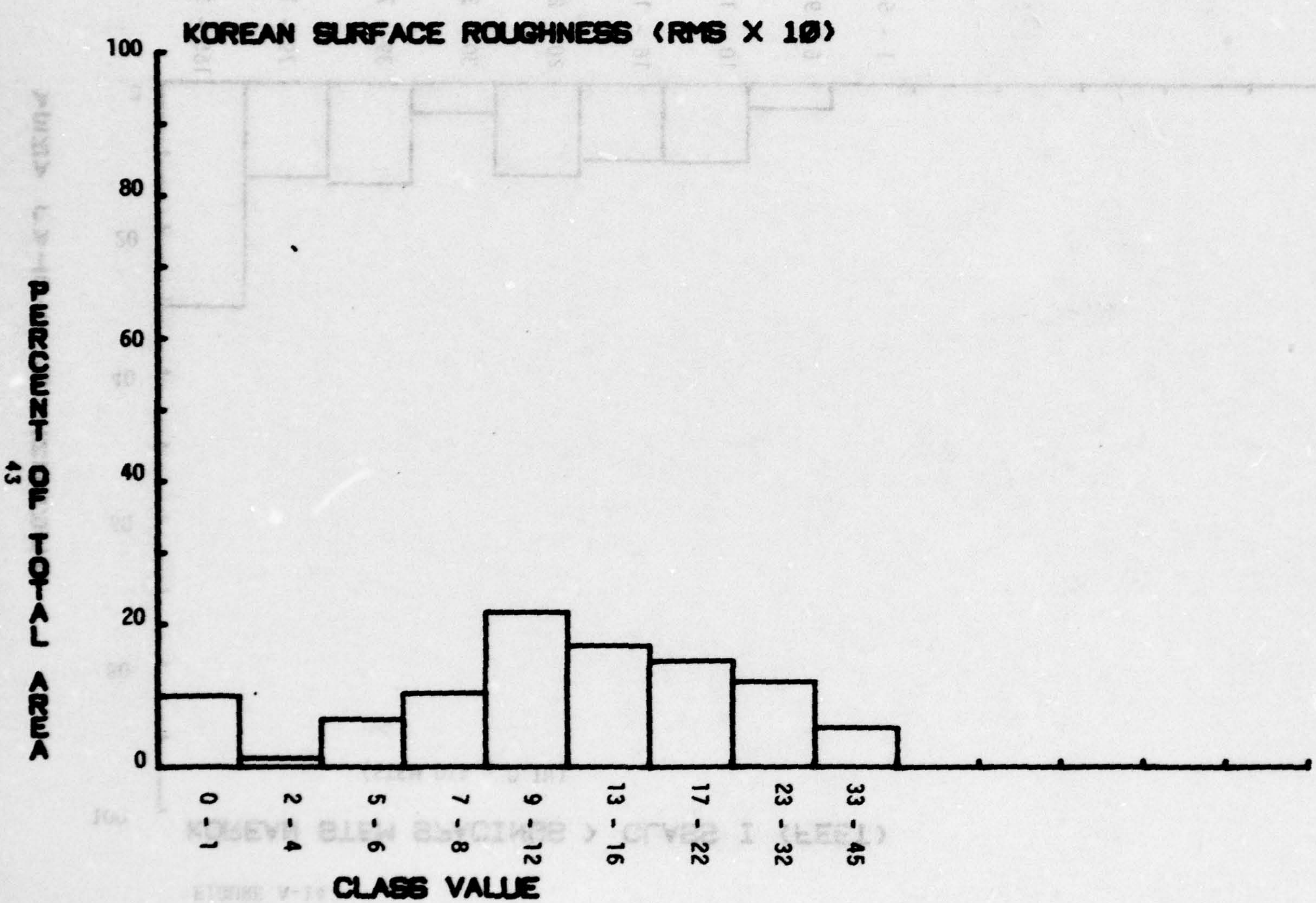


FIGURE A-13



KOREAN SURFACE ROUGHNESS (RMS X 10)
100
80
60
40
20
0
PERCENT OF TOTAL AREA
0 - 1
2 - 4
5 - 6
7 - 8
9 - 12
13 - 16
17 - 22
23 - 32
33 - 45
CLASS VALUE

FIGURE A-14

KOREAN STEM SPACINGS > CLASS I (FEET)

(STEM DIA > 0 IN)

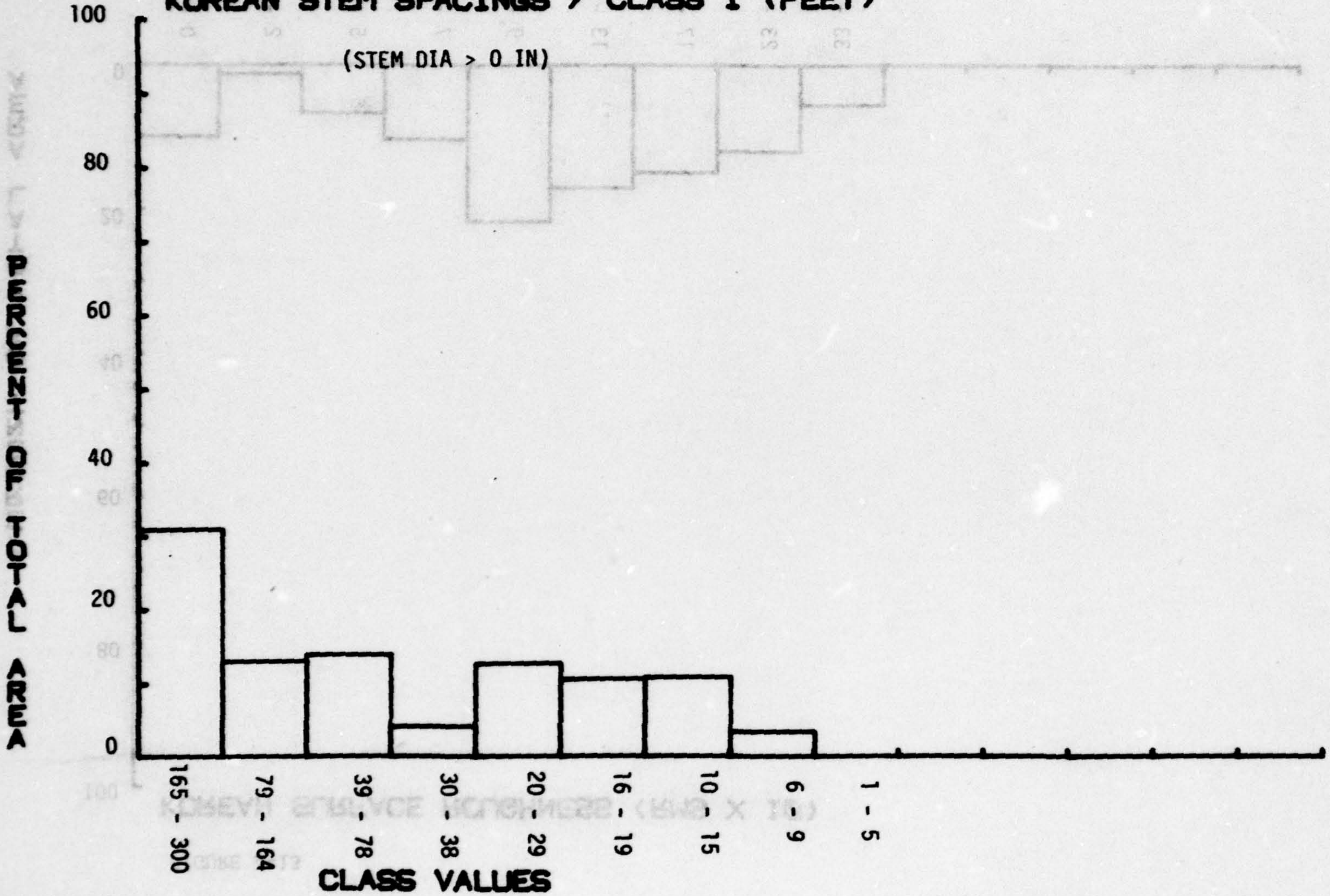


FIGURE A-15

KOREAN STEM SPACINGS > CLASS II (FEET)

(STEM DIA > 1.0 IN)

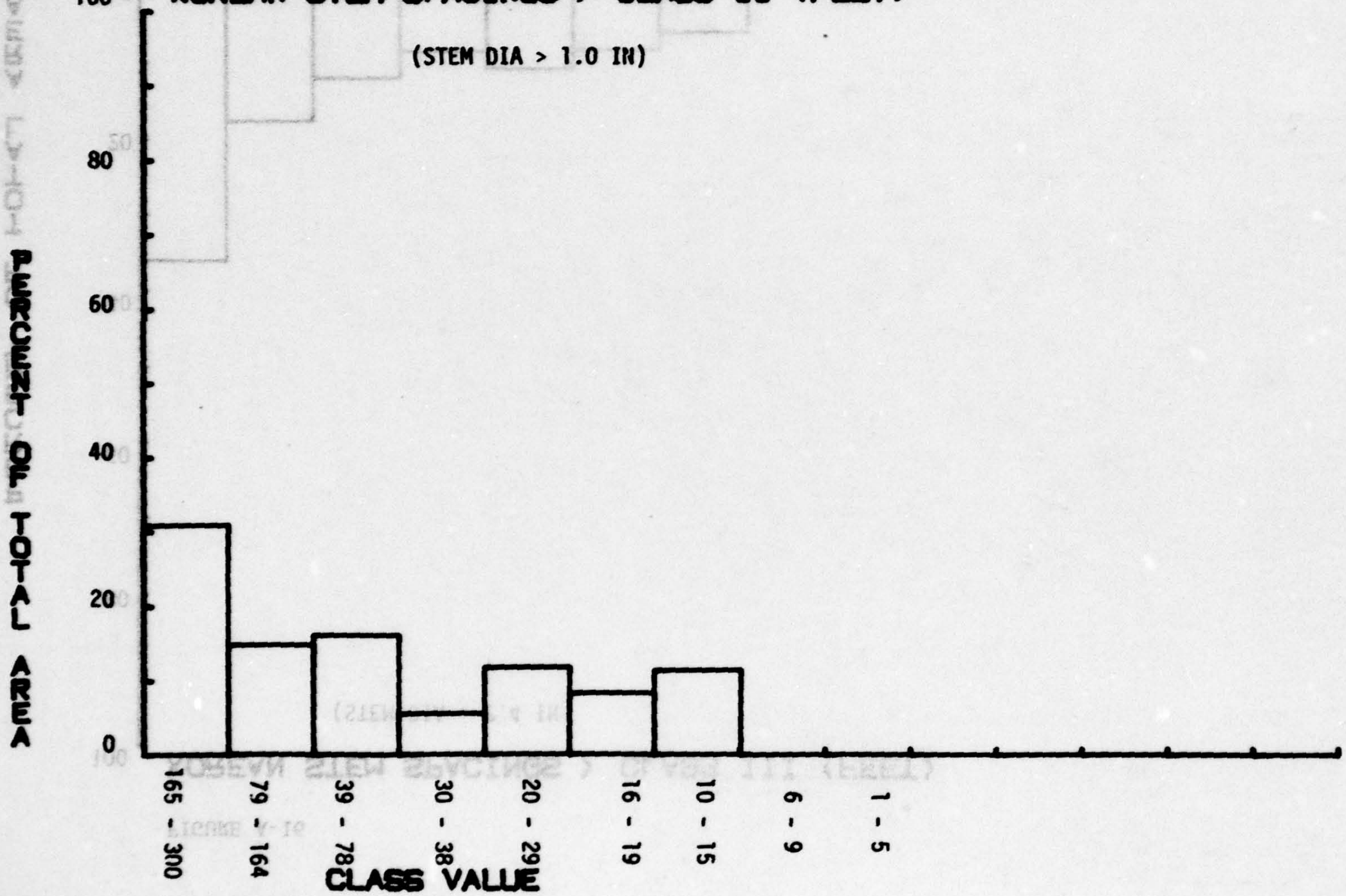


FIGURE A-16

KOREAN STEM SPACINGS > CLASS III (FEET)

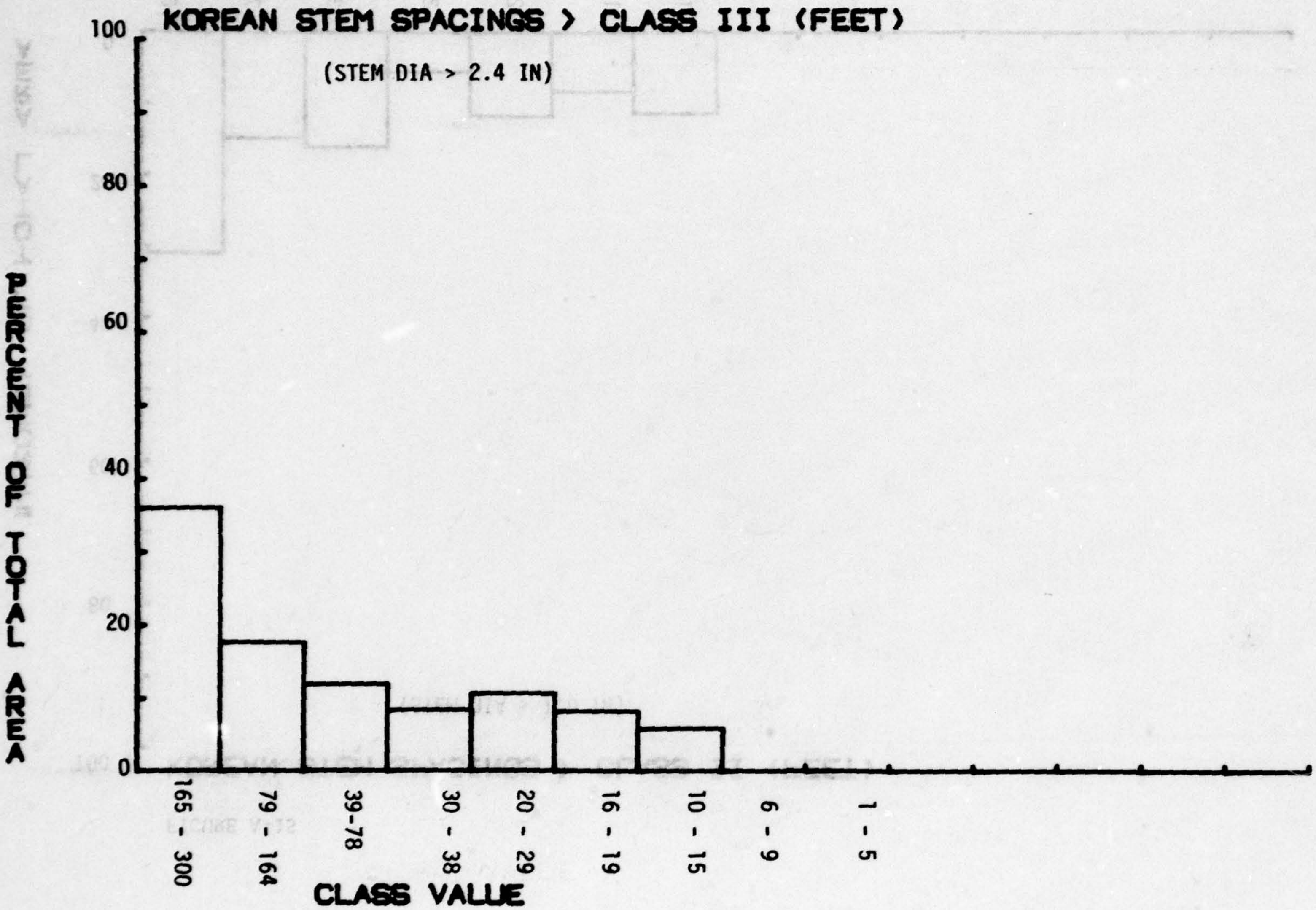


FIGURE A-17

KOREAN STEM SPACINGS > CLASS IV (FEET)

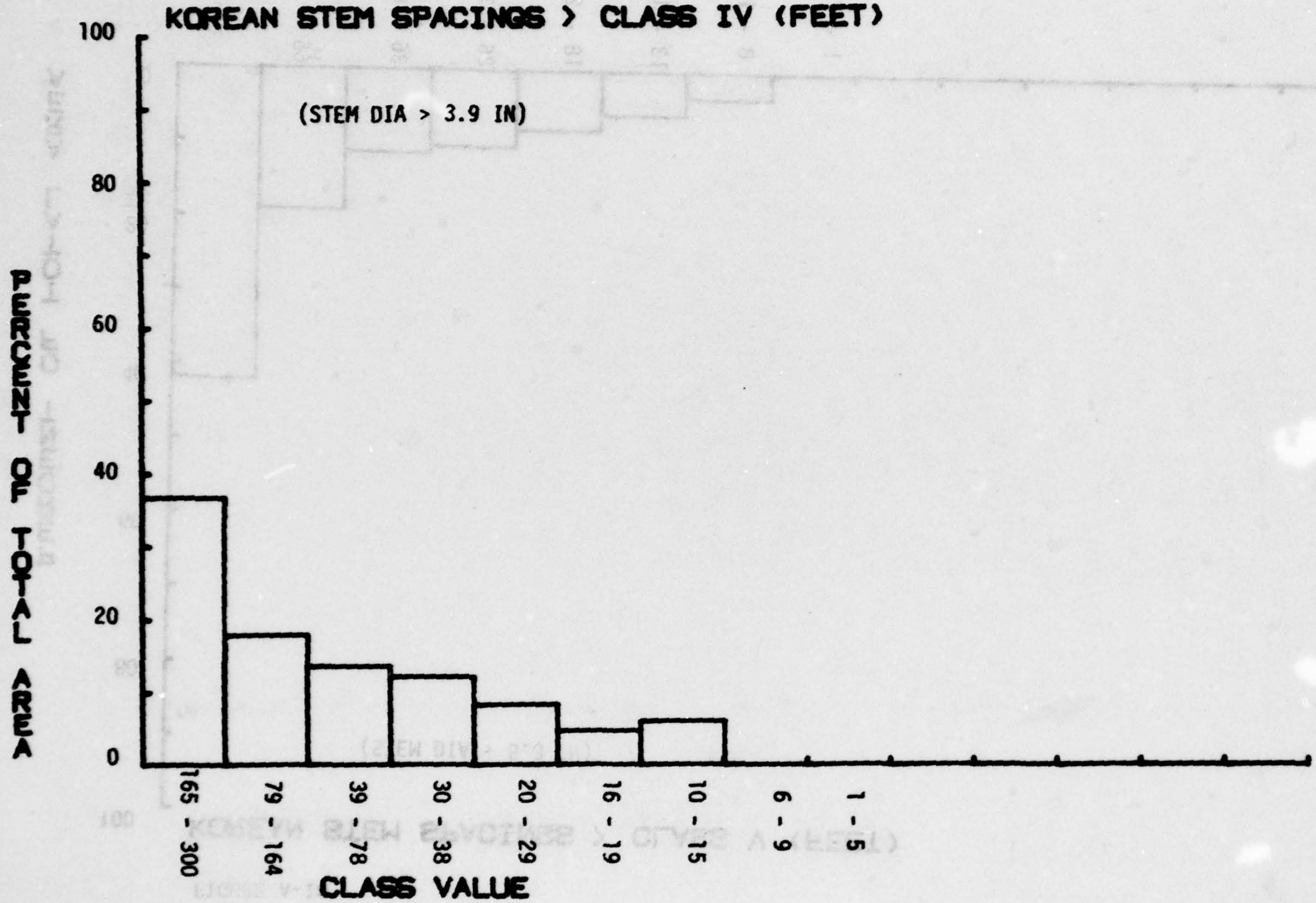


FIGURE A-18

KOREAN STEM SPACINGS > CLASS V (FEET)

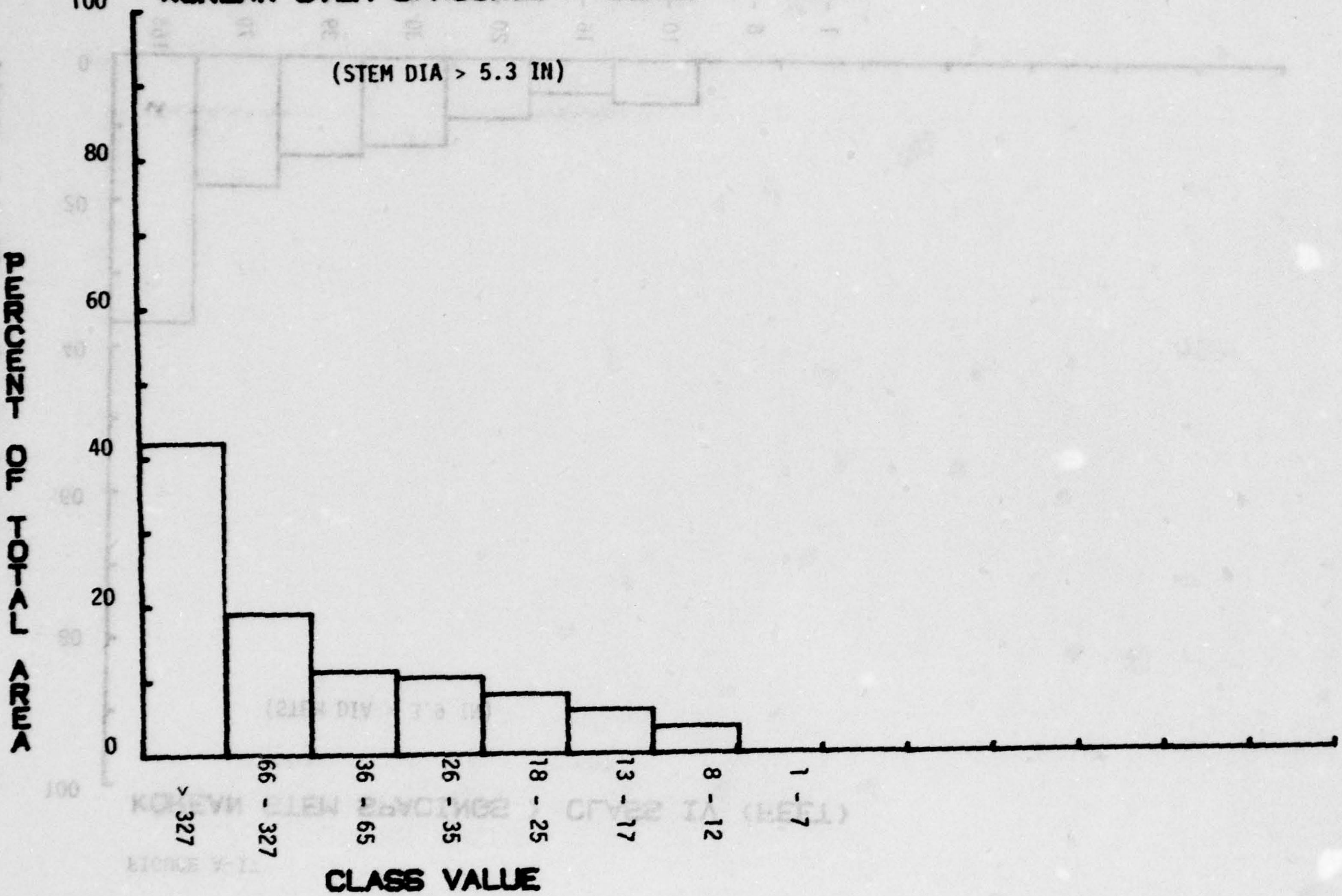


FIGURE A-19

KOREAN STEM SPACINGS > CLASS VI (FEET)

(STEM DIA > 7.0 IN)

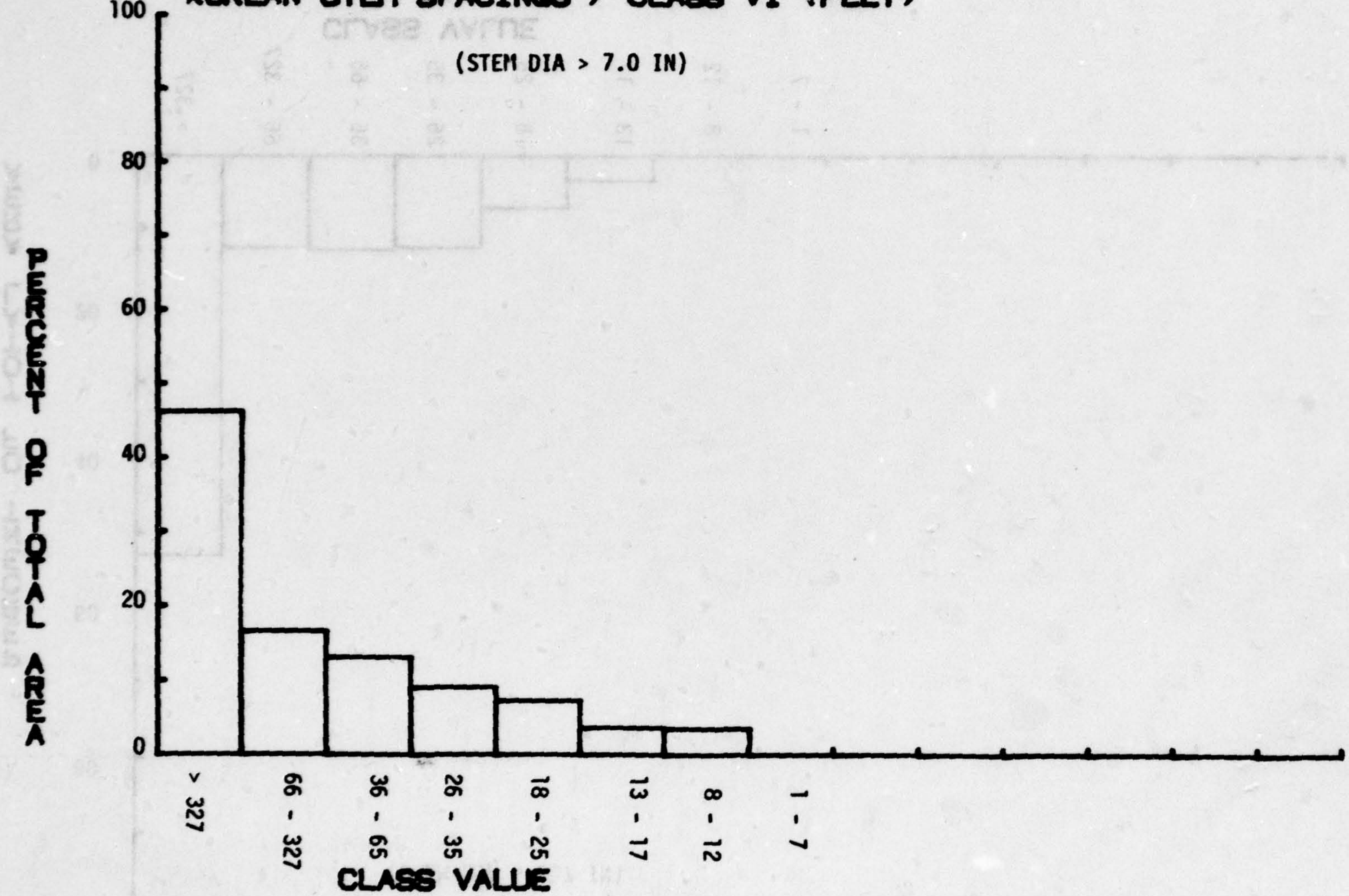


FIGURE A-20

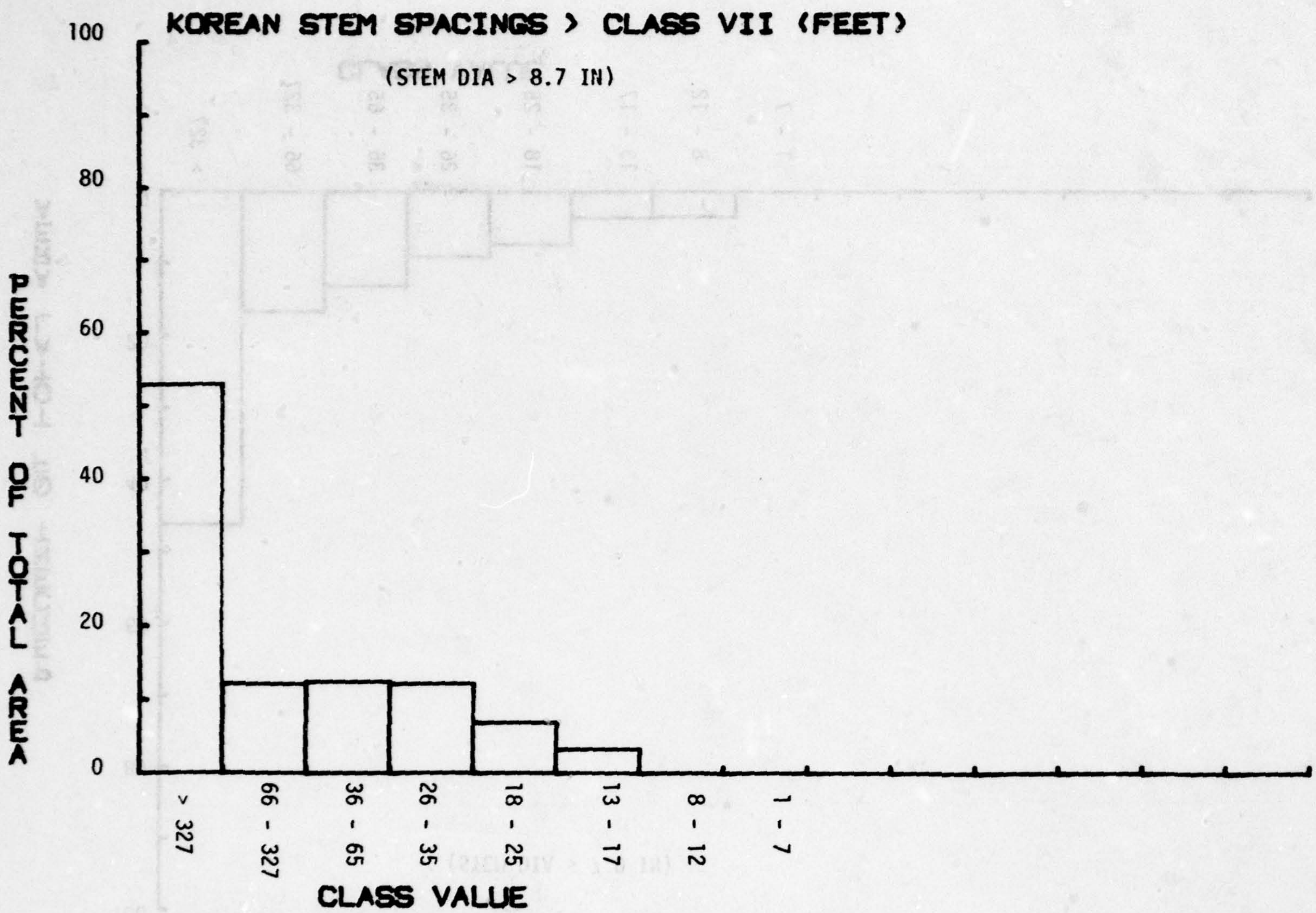

KOREAN STEM SPACINGS > CLASS VII (FEET)
(STEM DIA > 8.7 IN)
PERCENT OF TOTAL AREA
100
80
60
40
20
0
> 327
66 - 327
36 - 65
26 - 35
18 - 25
13 - 17
8 - 12
1 - 7
CLASS VALUE

FIGURE A-21

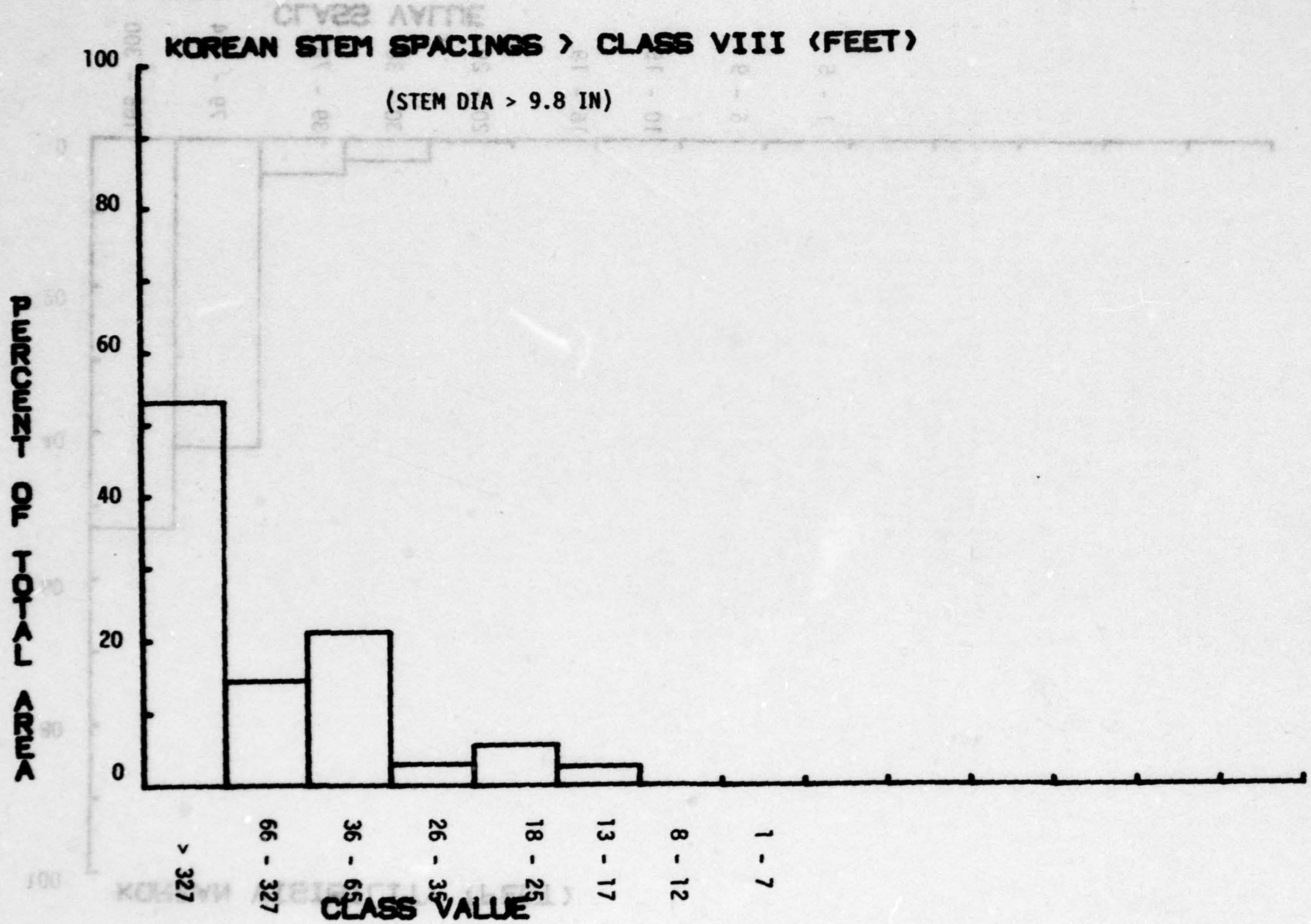

KOREAN STEM SPACINGS > CLASS VIII (FEET)
(STEM DIA > 9.8 IN)
PERCENT OF TOTAL AREA
100
80
60
40
20
0
> 327
66 - 327
36 - 65
26 - 35
18 - 25
13 - 17
8 - 12
1 - 7
CLASS VALUE

FIGURE A-22

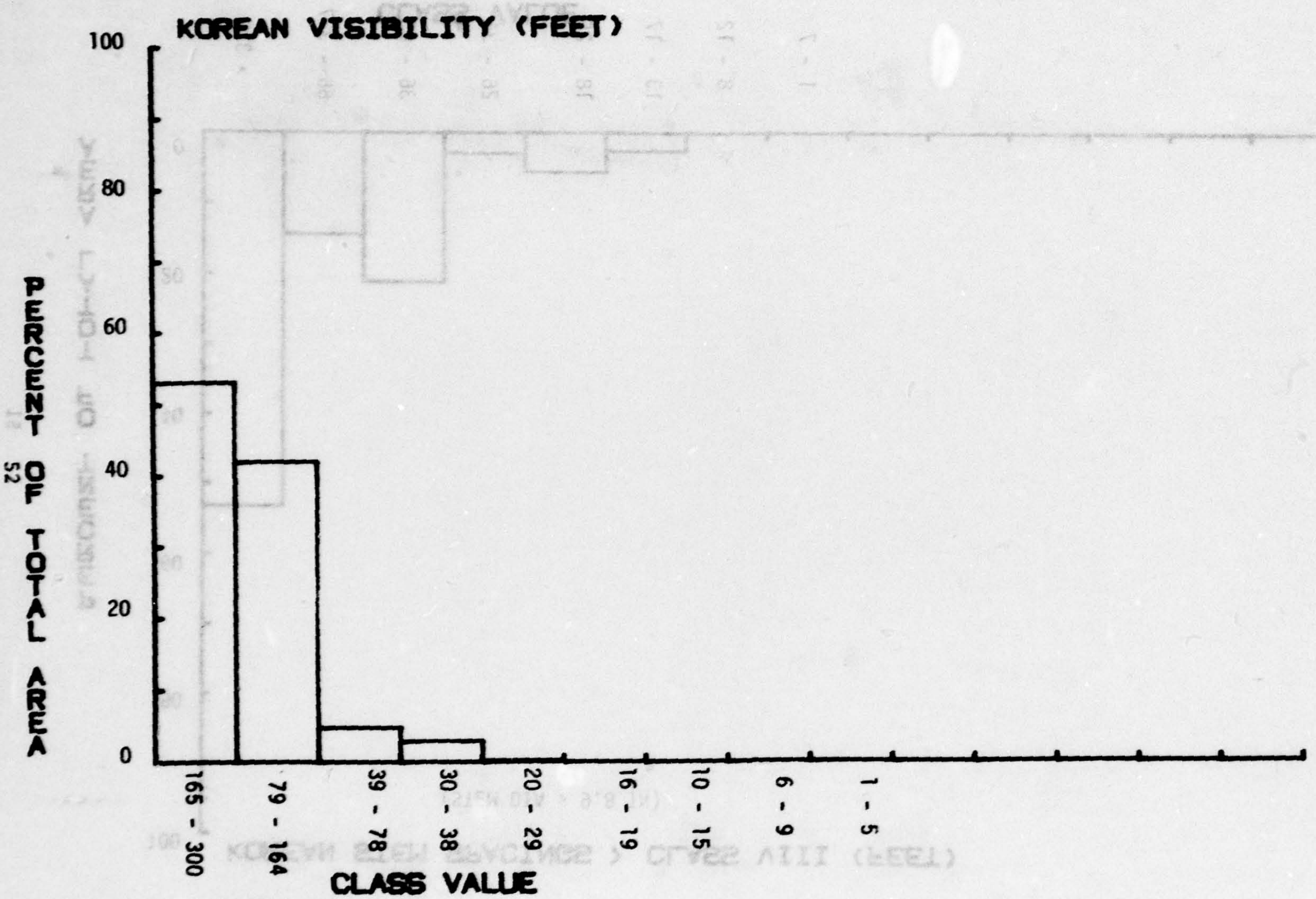
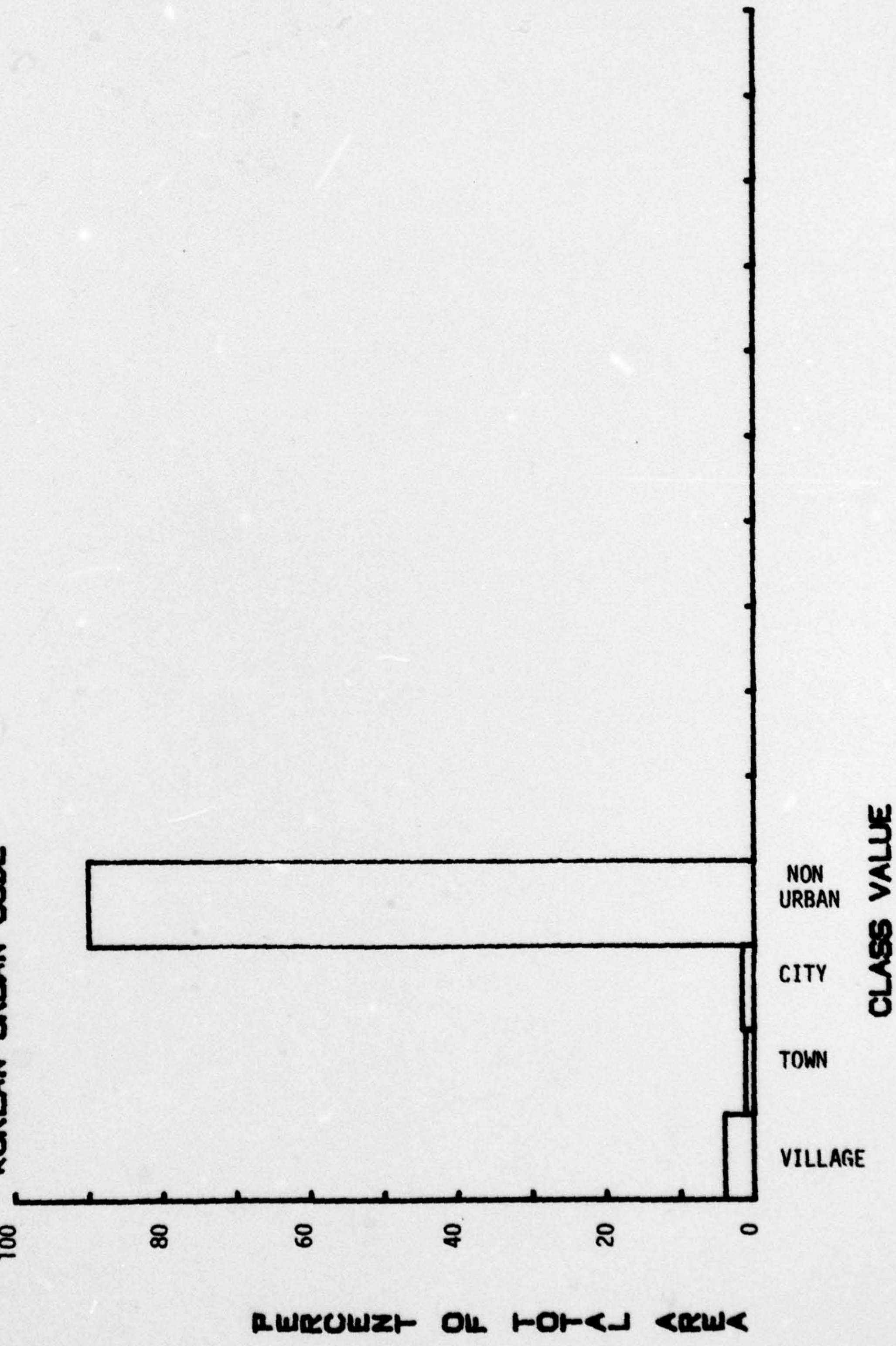

KOREAN VISIBILITY (FEET)
PERCENT OF TOTAL AREA
100
80
60
40
20
0
165 - 300
79 - 164
39 - 78
30 - 38
20 - 29
16 - 19
10 - 15
6 - 9
1 - 5
CLASS VALUE

FIGURE A-23

KOREAN URBAN CODE



Next page is blank

APPENDIX B

VEHICLE CONE INDEX EQUATIONS

Next page is blank

MOBILITY INDEX FOR SELF-PROPELLED TRACKED VEHICLES IN FINE-GRAINED SOILS

Vehicle ______________________________ Weight ____________

Track Description ______________________________________

$$\text{Mobility Index} = \left[\frac{(1) \times (2)}{(3) \times (4)} + (5) - (6)\right] \times (7) \times (8)$$

(1) Contact Pressure Factor = $\dfrac{\text{Gross weight, lb}}{\text{Area of tracks in contact with ground, sq in.}}$ = __________ = __________ (1)

(2) Weight Factor :
<50,000 lb = 1.0
50,000 to 69,999 lb = 1.2
70,000 to 99,999 lb = 1.4
100,000 lb or > = 1.8
= __________ (2)

(3) Track Factor = $\dfrac{\text{Track width, in.}}{100}$ = __________ = __________ (3)

(4) Grouser Factor :
<1.5 in. high = 1.0
>1.5 in. high = 1.1
= __________ (4)

(5) Bogie Factor = $\dfrac{\text{Gross wt} \div 10}{\text{Total no. bogies in contact with ground x area of 1 track shoe}}$ = __________ = __________ (5)

(6) Clearance Factor = $\dfrac{\text{Clearance, in.}}{10}$ = __________ = __________ (6)

(7) Engine Factor :
>10 hp/ton = 1.00
<10 hp/ton = 1.05
= __________ (7)

(8) Transmission Factor =
Hydraulic = 1.00
Mechanical = 1.05
= __________ (8)

$$\text{Mobility Index (MI)} = \left[\frac{\quad x \quad}{\quad x \quad} + \quad - \quad\right] x \quad x \quad = \_\_\_\_\_\_$$

$$VCI_{50} = 19.27 + .43\,MI - \left[\frac{125.79}{MI + 7.08}\right]$$

$$VCI_{50} = 19.27 + \quad - \quad = \boxed{\quad}$$

$$VCI_1 = 7.0 + .2MI - \left[\frac{39.2}{MI + 5.6}\right]$$

$$= 7.0 + \quad - \quad = \boxed{\quad}$$

Next page is blank

DISTRIBUTION LIST

NO OF COPIES	ORGANIZATION
12	Commander Defense Documentation Center ATTN: TCA Cameron Station Alexandria, VA 22314
1	Commander US Army Materiel Development and Readiness Command ATTN: DRCDE-F 5001 Eisenhower Avenue Alexandria, VA 22333
1	Commander US Army Materiel Development and Readiness Command ATTN: DRCBSI-L 5001 Eisenhower Avenue Alexandria, VA 22333
1	Commander US Army Materiel Development and Readiness Command ATTN: DRCPA-S 5001 Eisenhower Avenue Alexandria, VA 22333
1	Commander US Army Waterways Experiment Station ATTN: WESFM Vicksburg, MS 39180
2	Director US Army TRADOC Systems Analysis Activity ATTN: ATAA-SA ATAA-T White Sands Missile Range, NM 88002
2	Commander US Army Tank Automotive Research & Development Command ATTN: DRDTA-UL (Tech Lib) DRDTA-V Warren, MI 48090
2	Chief Defense Logistics Studies Information Exchange US Army Logistics Management Center ATTN: DRXMC-D Fort Lee, VA 23801
1	Commander US Army Concepts Analysis Agency 8120 Woodmont Avenue Bethesda, MD 20014

Aberdeen Proving Ground

Cdr, USATECOM
ATTN: DRSTE
DRSTE-CS-A
Bldg 314

Dir, BRL, ATTN: STINFO Br, Bldg 305

Dir, BRL, Bldg 328
Dir, HEL, Bldg 520